THE UNIVERSITY OF ALBERTA

INDIVIDUALIZING MATHEMATICS INSTRUCTION FOR THE ADOLESCENT MENTALLY HANDICAPPED STUDENT AN EVALUATION OF THE NETWORK APPROACH

by

© ISABEL A. EVANS

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ABSTRACT

This study is concerned with the problem of teaching mathematics to the adolescent mentally retarded student. By using a network approach to curriculum planning, it describes how individualization of instruction in mathematics is provided for a large number of retarded students attending a vocational school in Edmonton, Alberta.

The study is further concerned with an evaluation of this approach by making comparisons of students' achievement in arithmetic computational skills with their achievement during previous years when a traditional approach to teaching arithmetic was used.

Five groups of students were identified. Comparisons were made of gains made by students at similar year levels in the two programs. No differences were found to exist.

Additionally, each of the five groups of students were subdivided into students of relatively high or low I.Q. Comparisons of gains in computational skills between students of similar I.Q. and similar year levels in the two programs were made.

In one comparison between high I.Q. groups a significant difference was found to exist suggesting that with these students the network approach was marginally more efficient than the traditional program in terms of gains made. No differences were noted between the low I.Q. groups. Subjectively, teachers perceived the program to be effective and were unanimous in their preference for the organizational approach of the network program over the traditional program previously in effect.

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I. INTRODUCTION

The concern of educators and the general public with the problem of children in need of special education has grown over the last decade as an increasing number of children are being identified as unable to profit from the education available in the regular grades. The result has been a proliferation of special classes, learning centres, adaptation classes, remedial programs, resource rooms, special schools, etc., depending on the current philosophy of the period as to whether integration or segregation of mentally retarded children should be practised. These have all been set up at great expense with the express intention of providing an effective education for these children. It is unfortunately true that many of these programs are not justifiable in terms of educational achievement and where they are, there is little objective evidence to show that progress is occurring.

In a review of the research in 1964, Kirk reported that the value of special programs for the mentally handicapped was 'disappointing'. Similarly Blackman (1967) cited studies by Blatt (1958), Ellenbogen (1957) and Thurstone (1958) which confirmed the superior academic performance of children retained in regular classes. A longitudinal study (four years) by Goldstein, Moss and Jordan (1965) confirmed that for the majority of children with learning problems special classes had not succeeded in producing significantly better achievement than regular classes.

The situation was summarized by Johnson (1962),

> "It is indeed paradoxical that mentally handicapped children, having teachers specially trained, having more money per capita spent on their education and being designed for their unique needs should be accomplishing at the same or at a lower level than similarly handicapped children who have not had these advantages and have been forced to remain in the regular grades." (p. 66).

It is a surprising fact that in spite of the trend toward accountability, it is impossible to discover from the literature, whether the situation existing today is any different from that described by Johnson. Although short term specific research has been carried out with small numbers of students, there is a dearth of longitudinal large scale studies made of children receiving special education within an established system of public education.

This present paper attempts, in a small way, to partially fill this void by presenting a longitudinal study of the arithmetic achievement of two hundred adolescent mentally handicapped students enrolled in a special school.

Trends in Special Education

There appear to be two divergent trends in special education. One school of thought takes the attitude that the problems of the mentally handicapped child arise from a basic deficiency in such areas as retention, attention, ability to generalize, form abstractions and see relationships, problems, which in the eyes of the investigator have arisen as learned behavior. Treatment, therefore, hinges upon ignoring the etiology of the problem and concentrates upon manifest behavior, attempting to bring about changes by using conditioning techniques that substitute behavior that is compatible with learning for the previous incompatible behavior.

Exemplifying this approach is the work of Das (1972), Ellis (1963), McIntyre and Dingham (1963) and Spivach and Levine (1962).

An alternative approach is represented by such work as Zigler (1969) who views the problem of mental retardation as one that arises from slowness of cognitive development with the cause of the delay being either organic deficits giving rise to problems in the central processing systems or to perceptual problems that affect cognitive development. Problems in learning from this viewpoint arise because of the immature nature of the intellectual structures available for the retarded child in relation to his chronological age.

For the teacher of the mentally retarded child, these hypotheses are not mutually exclusive, and in practise he may use teaching strategies that may have a theoretical basis in either of the two approaches. Particularly with the older student for whom 'time is

running out' an empirical approach may well be followed, that makes no attempt to remediate but concentrates on working within the limits of the student's functioning to bring him to a level of academic achievement which is compatible with an independent adult life.

Trends In Instructional Practices For Teaching Mathematics

The two divergent trends previously mentioned have given rise to a variety of instructional practices for teaching mathematics to mentally retarded children. Compatible with the first trend are those methods which stress language and verbal information processing, such as the 'Distar' program Englemann and Bruner (1969), Englemann and Carmine (1969). Programs such as Hewitt's Engineered classroom (1967) which utilizes principles of behavior modification also fall into this category. Precision teaching (Lindsley, 1965) and programmed instruction (Bijou, Birnbrauer, Kidder and Tague, 1966) similarly look to learning theory as the basis for their techniques.

The alternative or developmental approach has adopted arithmetic programs that recognize the retarded cognitive development of the mentally retarded child and attempt to remediate this by a discovery or manipulative approach to teaching concepts of number. Piagetian theory is the basis for many of these programs. Examples are, 'Mathematics for Schools', Fletcher (1971), 'Investigating School Mathematics', Addison Wesley (1973) and 'Math-Activity', Stott (1974). The Stern (1958) and Dienes (1959) programs may also be categorized as developmentally based.

Of recent years a potentially valuable model for teaching arithmetic to mentally retarded children has been that advanced by Cawley and Vitello

(1972) who have attempted to provide a framework within which varied aspects of the arithmetic curriculum may be accommodated.

In essence, four integrated units form the basis for the related instructional system. A 'learning to learn' component forms one learning unit and is concerned with types of learning, retention and factors which influence learning such as meaningfulness. The interactive unit is divided longitudinally into input from the instructor, and output from the learner. Vertical division is into modes of interaction between the learner and teacher, thus providing for a variety of responses at differing levels of difficulty. The third unit is that of verbal information processing, and is concerned with verbal problem solving strategies. It attempts to specify the various components of verbal problems, and suggests that monitoring of the language structure is necessary so that there is a sequential progression from simple to more complex constructions.

The cognitive processing unit is composed of two sub-units:

(1) those behaviors which appear to be influenced by instruction, interest and experiment, and

(2) Those behaviors in which maturation seemingly cannot be enhanced by direct intervention, that is, the developmental stages postulated by Piaget.

Related to these units is an instructional system delineated into four areas. The first is concerned with suggested instructional materials, e.g. audio tapes, etc. The second unit consists of the

arithmetical strands to be included in the program. These are (1) patterns, (2) set identity, (3) set operations, (4) number operations, (5) measurement, (6) geometry, and (7) fractions. The third unit is concerned with the necessary cognitive processes, e.g., classifying and synthesizing. The final unit is concerned with evaluation required for planning a particular child's program. The authors suggest that in addition to the more customary forms of objective evaluation, an analysis should be made of the child's developmental level in Piagetian terms, that is determining whether his cognitive development is still at the pre-operational stage or has advanced to the concrete or formal operational level. Many programs could be structured around this model and it is probable that most would succeed in improving functioning in arithmetic. Most experienced teachers appear to use a variety of different approaches to cater for the wide disparities seen in the special class. The aspect that is lacking in them is the solution to the practical problem of how to provide a program at many differing levels of achievement to many different students each with his own particular learning style and his own idiosyncrasies. It is this aspect of individualization that gives the network approach which will be described, its unique quality.

Background to the Present Study

In the 1960's the trend in special education in Canada was to establish segregated schools and classes for the retarded child. In 1968 Edmonton Public School Board opened a vocational school catering for some 450 students of Junior and Senior High school age (12½ to 20)

all of whom because of intellectual retardation, could not benefit from the programs offered in the regular school system. On the Wechsler Intelligence Scale, the students ranged from I.Q.'s of approximately 50 to 85.

In the spring of 1970 annual administration of the Wide Range Achievement Test (W.R.A.T., Jastek & Jastek, 1965) was instigated and this has been continued on a yearly basis. This test is a brief individual test of word recognition, spelling and arithmetic. It yields a Grade level score for each section that ranges from kindergarten to Grade 12. The arithmetic section is a written test that takes approximately fifteen minutes for low achieving students to complete. For students scoring below Grade 1.8 an oral section is administered. This test was selected for use for reasons of ease of administration, time and because it was seen as less threatening to the students than tests used previously. Wechsler Intelligence scores were also available on each student.

In 1973, the Edmonton Public School Board funded an innovative curriculum development program in academic areas which became known as the 'network' system. By 1976 there thus existed a considerable amount of objective data on educationally retarded children and also an experimental program that had been in existence for some three years that had not been objectively evaluated.

The present study is an attempt to investigate objectively the value or otherwise of the network approach to teaching mathematics by examining the changes that have occurred over time in the student's

computational skills, that is the four basic operations of addition, subtraction, multiplication and division, both with whole and fractional numbers.

Comparisons will be made between comparable groups of students prior to, and after, the introduction of the network system. Comparisons will be made of the progress students achieved before and after they were placed on the network program.

Organization of the Study

The study consists of two sections; these are:

1. A description of the development and content of the network curriculum as applied to mathematics, together with an outline of the day to day organization of the program.

2. An objective evaluation of the program.

    a. When comparisons are made between groups of students at the same year level of the school program, is there any evidence to indicate that the network program produced greater mean gains in arithmetic computational skills? (This involves examining different groups of students at the same year levels in the school program).

    b. Is there any evidence to show that the program is more effective with students of relatively higher or lower I.Q.?

This study is therefore presented with a dual purpose. The description of the network approach to curriculum planning demonstrates a practical method of individualizing programs for large numbers of students whose functioning and intellectual level vary widely and suggests a methodology that can be applied in many areas. The statistical study illustrates that such an approach can be successfully applied by classroom teachers working in a conventional school system.

II. REVIEW OF THE RELATED LITERATURE

Chapter II consists of two sections, organized as follows:

Section 1

Research related to mathematics teaching and the mentally retarded child.

i. Studies related to arithmetic development and studies of specific methodology,

ii. Studies related to general characteristics of arithmetic ability in the mentally retarded child.

Section 2

Research related to the concept of a network approach to curriculum development.

MATHEMATICS TEACHING FOR THE MENTALLY RETARDED CHILD

Specific Methodology and Arithmetic Development

Goldstein, Moss and Jordan (1965) as part of a study designed to evaluate the efficacy of special classes for mentally retarded children, used arithmetic achievement as one criterion. The progress of children retained in regular grades was compared with that of children assigned to special classes. Those retained in regular grades received a traditional approach to number whilst the special classes received either a readiness program stressing rote counting, recognition of symbols and vocabulary, or a program that stressed understanding, rather than computational skills. Number was stressed in its context rather than in a formal setting.

After four years, only those children with I.Q. below 80 appeared to have benefited from the special class program, being significantly superior to the control group in computational skills and problem solving.

Klausmeier (1959, 1962), supports the contention that retarded children can learn reasoning skills if the curriculum is geared to their level. Giving an arithmetic learning task appropriate to the child's achievement level, he found that whilst the retarded child took longer to acquire the learning, over a period of eighteen weeks, the rate of retention and ability to transfer to a similar task did not differ from that of the normal or high I.Q. child. He concluded that around the chronological age of nine or ten years, the child with an I.Q. of between 55 - 80, can acquire arithmetic learning quite efficiently, providing the material is 'potentially meaningful'.

The School Mathematics Study Group, has developed materials for the low achieving Junior High School pupil. Devenney (1972) evaluated the program with students achieving at least one year below grade level. Using those aspects of the S.M.S.G. Secondary School program which it was felt the under-achiever could handle, the lessons were presented in worksheet format, with reading and computation kept to a minimum.

After two years there were still serious deficiencies in achievement (2.5 years below grade level) and no significant differences were found on application skills between the experimental and control groups, the control made greater gains on computational skills. The experimental group made significantly greater gains on scales designed to measure other mathematical concepts, and perhaps more importantly, now liked mathematics, whereas the control group was even more negative

than at the start of the study.

Bradfield (1973) investigated the efficacy of precision teaching for retarded children returned to regular grades. Both normal and retarded children received the individualized approach of precision teaching. The study involves a very small sample (three retarded children in each of two classes). Significantly greater gains in arithmetic, were made by one group of retarded children when compared with similar children retained in a special class. The report does not state in what area gains were made, nor provide evidence as to the comparability of the teaching procedures.

A problem that occurs in many studies is to determine the teaching methods used and the content of the programs. 'Teacher designed material, that meets the student's need and level', is not particularly helpful.

In the area of teaching techniques and instructional programs, there is little empirical evidence for their value, although they are cited readily enough in many general texts for teaching retarded children. The following two studies are of specific methods, commonly used with normal children, evaluated as to their usefulness with mentally retarded children.

Using 'Cuisenaire' rods, Callahan and Jacobson (1967) working with subjects of low I.Q. (57 - 80), considered that the children had learned to recognize inverse operations and the commutative property of addition, they better understood the use of signs, and there was transfer to oral arithmetic. The authors suggest that these results show that retarded children are capable of making mathematical 'discoveries'.

Ives (1962) used the Stern Structural Arithmetic Program (1958) with retarded children and compared it with a 'meaning' approach. Both approaches were equally successful.

Perhaps because no one reports unsuccessful programs, the research does little to indicate which are the programs and methods of choice for teaching mentally retarded children arithmetic skills. However, it does appear that given favorable circumstances, the retarded child can make progress in arithmetic. In a poorly reported study of 'Systematic Instructional Procedures' used with mentally retarded disadvantaged children, Haring, Maddox and Krug (1971) claimed a mean gain in one year using W.R.A.T. scores of 1.61 grades compared with a gain of .48 in a regular disadvantaged classroom. Not stated are the ages or I.Q. level of the students concerned.

Pointing again to the wide variety of methodology which appears to be successful with retarded children is the report by Armstrong (1968, 1969) in which comparison was made between a 'deductive' and an 'inductive' style of presentation. Whilst a varied form of repetition appeared to be more successful with the inductive mode, and an exact form of repetition more successful with the deductive mode, the mode itself did not appear to have an effect on the final results.

In the network approach to be discussed, a wide variety of self-instructional teaching machines are used. The research appears to suggest that this is a valid approach. Blackman and Capobianco (1965) evaluated programmed instruction with the retarded utilizing teaching machines. Greater gains were made in arithmetic by mentally retarded

children when this method of instruction was employed. Improvement in deportment and general social behavior was also shown. They suggest that the hierarchical structure of arithmetic lends itself to this form of instruction whilst reduction in frustration might account for behavior improvement.

Price (1963) found that whilst there was little difference in achievement between students taught by machines and those taught more conventionally, the former took considerably less time to cover particular topics.

Kelly (1967) investigated teaching basic facts by rote, understanding and commercially produced programs. Providing the reading level of the student was above Grade 2.3, the machine instruction was the most effective in improving arithmetic reasoning skills. Rote learning was most efficient for learning basic number facts.

The implications of the foregoing research appear to be that any curriculum and any methodology can be effective in bringing about gains in arithmetic with the mentally retarded child, always providing that it is geared to his level of cognitive development, his functioning level and his particular idiosyncratic learning style.

The General Characteristics of the Arithmetic Ability of the Mentally Retarded Child

Few generalizations may be made about the arithmetic achievement of the mentally retarded child. A wide range of abilities may be expected to be found in children with a relatively homogenous intelligence level.

Jarvis (1964) found that at the sixth grade level, children with an I.Q. of below 94, could vary from five to seven years in their ability to do arithmetic. He concluded 49% would be below grade level, 14% at grade level and 37% above.

Cruikshank (1948 a, 1948 b, 1948 c) compared the arithmetic behavior of retarded children with normal children of similar mental age. He found that the retarded child has problems in differentiating relevant from irrelevant material. His reasoning ability is inferior but in straightforward computational skills his performance is similar to that of the normal child. There appeared to be little understanding of the procedures that were used, and difficulty in deciding the operation required. Concrete aids were used more frequently and zero was a difficult concept.

In general, Dunn (1954) and Bensberg (1953) concluded that the mentally retarded child, tends to resemble his mental age peers in computational skills but in reasoning and problem solving he is often at a significantly lower level.

Cawley and Goodman (1968) investigated the relationship between Thurstone's Primary Mental abilities with academic achievement in mentally handicapped children. At a younger age there was a close correlation between all aspects of number with verbal and motor abilities. In older children the achievement level for computational skills was much higher than the achievement level reached in reasoning or conceptual skills, and a significant correlation existed between reading and computational skills. Possibly reasoning and understanding had been neglected in favor of computational skills. Obviously these skills are

necessary, but their value is limited if the child is unaware of the operation called for in the problem.

Bower (1970) suggested that her findings that the retarded child, when compared with normal children of similar mental age, was superior in the areas of multiplication, division, time and calendar, were due to their longer exposure to schooling and emphasis on functional maths.

There has been a considerable amount of research related to the mathematical abilities of retarded children in terms of Piagetian stages. Woodward (1961) and Hood (1962) found delays in the development of logical reasoning which appeared to equate with difficulties in arithmetic abilities.

Wheatley (1970) examined the relationship between the ability to cardinate, count and conserve and first grade arithmetic. He concluded that conservation was the best single predictor of achievement. In general, researchers in this area have found that difficulties in problem solving areas of mathematics are most closely linked with Piagetian stage development. Seemingly many computational skills can be acquired in a rote form without an underlying understanding.

In a review of the research that compared arithmetic performance of mentally retarded children with children of similar mental age, Connolly (1973) concluded that the mentally retarded are inferior in their ability to solve abstract and verbal problems, in their ability to solve concrete problems, in their understanding of the operations required to solve problems, in their ability to isolate pertinent data and in their work habits.

Some general conclusions may be drawn from these aspects of research.

1. The arithmetic skills of mentally retarded children vary widely. 'Labels' cannot be applied in this regard.
2. In general, computational skills equivalent to those possessed by children of similar mental age may be acquired by mentally retarded children but frequently a lag is found in their understanding of concepts and reasoning abilities.
3. Provided that the content is at the child's level of difficulty, his ability to learn, retain and transfer is comparable with that of the normal child.
4. A wide variety of teaching methods appears to be successful in teaching computational skills, but there is little objective evidence to suggest which instructional methods will promote comparable progress in developing reasoning skills or an understanding of the processes and concepts of number operations.

A Network Based Approach to Curriculum Development

Since the original application of systems analysis techniques was to industrial production, it is understandable that early attempts to modify the techniques to be applicable to curriculum development were in the field of vocational education. Young (1972) describes how such an approach might be utilized to teach welding theory. He suggests that the value of the methodology lies in it being particularly suited to provid-

ing individually prescribed instruction for students of varying levels of ability and in the improvement in teacher efficiency that results from the system.

Hathaway (1970) designed a network approach to curriculum planning based on Program Evaluation and Review Techniques (PERT, Tanner, 1971) principles and discussed the validity of such an approach in the light of current theory of curriculum development. A pilot study relating to the teaching of a Senior Science program was developed (1971).

As a result of this initial project, Hathaway (1975) carried out a feasibility study to determine the practicality of the network approach as a method for selecting and organizing curriculum content and managing information and student records in such a way as to make individualization of instruction a practical proposition. Irvine and Kupchenko (1973), Irvine, Kupchenko, McElroy (1974) describe some of the early implementation of the approach.

Hathaway used the subjective evaluations of some 50 teachers and administrators who had been involved with the project at elementary, secondary, special and post-secondary levels to determine the feasibility of the network approach. He concluded that the approach was perceived by teachers to be more effective and efficient than other alternatives with which the teachers were familiar. The respondents considered its implementation was feasible for use in the classroom with teachers working in remedial or special classes being more enthusiastic than regular classroom teachers.

No objective evaluation in terms of comparisons of progress in conventional school subjects was carried out.

III. THE DEVELOPMENT OF THE NETWORK - BASED CURRICULUM AT L. Y. CAIRNS SCHOOL

1. Background

The mathematics curriculum used at the school prior to the development of the network was somewhat unspecific. Teachers used material with which they were familiar and methods and record keeping systems that varied from class to class. Many of the classroom teachers were also responsible for organizing and teaching other subjects.

This unstandardized approach led to problems as classes changed from year to year. Difficulties arose with regard to determining each student's functioning level and, since the class composition was altered, problems arose as to which students had covered which topics.

The system also led to duplication of effort since many teachers might be teaching the same concept and each would be preparing his own material. Commercial programs and equipment might be purchased and used by one teacher, thus leading to inefficient use of resources.

The students in a particular class, although of similar chronological age, presented a wide range of problems and functioning levels. Grouping was usually done on the basis of similar reading scores, so that for mathematics it was possible for there to be a range of functioning from readiness to approximating Grade 6 levels. This heterogeneity of functioning would also be compounded by a wide variety and incidence of physical and emotional problems.

It was thus apparent to the teachers concerned, that if progress

was to be made in teaching mathematics, then the following objectives must be met.

1. To produce a more specific curriculum.
2. To set up a program that catered to the individual needs of each student.
3. To devise a methodology that would allow each student to work independently.
4. To produce or select suitable instruments for diagnosis and evaluation.
5. To avoid duplication of teacher effort.
6. To institute a common method of record keeping that was continuous from year to year.
7. To institute a centralized pool of resource material easily accessible and retrievable.

In connection with the feasibility study planned by Hathaway and previously described in Chapter II, a research grant was made available to the school by the Edmonton Public School Board, which funded the purchase of resource material and allowed for the initiation of the program. Modifications to the original program are occurring continuously as new needs are recognized.

The school is organized by year levels on the basis of chronological age. Students between the ages of 12½ to 13½ are placed in Year I, from 13½ to 14½ in Year II, 14½ to 15½ in Year III and 15½ to 16½ in Year IV. Students may continue in the school for a further three years as senior students with the emphasis being upon vocational training.

On an experimental basis the network program was used with selected Year III and IV classes in the school year 1973 - 1974. The following year (1974 - 1975) all the students from Year I to Year IV were included in the program and in the school year 1975 - 1976 it was extended to include the entire student population of about 450.

The advantages of a network approach were seen to be:

1. The totality of the overall program, both content and sequence, may be seen at a glance because of the graphic presentation that is used.
2. Individualization of instruction is possible.
3. Monitoring of progress by student and teacher is easily facilitated.
4. It possesses 'built-in' motivational and reinforcement qualities.
5. It allows for efficient use of resource materials and equipment.
6. Teacher time is used more effectively.

2. Construction of a Network Based Curriculum

The original concept of network based curriculum was derived from network based management technology developed in industry. Since industrial and educational objectives tend to differ, it is not surprising that certain aspects of this approach were found to be irrelevant to the instruction of handicapped children. Thus the time factor included in previous descriptions of the procedures involved (Hathaway, 1971), is not used in this application of the network approach. Modifications to Hathaway's original plan were introduced in the light of experience, the specific needs of the students and the resources available.

The following are the steps that are now seen to be essential in producing a network based curriculum. Following each step, and exemplifying it, is a description of that aspect of the program as it has been developed at L. Y. Cairns School.

1. Prepare a statement of the general aims and objectives of the curriculum (see Figure 1).
2. Organize a network that displays the major areas of study (see Figure 2). It should be noted that in the course of the program developed many of these major areas become integrated.
3. Break down each of the major areas into the specific concepts that are to be covered, arranging them in a sequential order deemed suitable, e.g., the order customarily used in a conventional textbook. One example of such a sequence is presented in Figure 3.
4. Prepare a statement of behavioral objectives for each of the concepts mentioned under the third objective. The behavioral objectives for one concept are presented in Figure 4.
5. Compile resource material for teaching each concept. Code and file appropriately. The materials for the concept detailed in Figure 4 are also included in that section. This resource material will be suitable for independent study by the student or for teacher directed instruction of individuals or small groups. The material will be used for:

   a. introductory and initial teaching for each concept.

   b. practice and further teaching of the concept.

Statement of General Aims and Objectives of the Mathematics Curriculum

1. To use mathematics as a vehicle through which logical reasoning abilities may be developed.

2. To teach students the basic arithmetical operations of addition, subtraction, multiplication and division with both whole and fractional numbers, and to apply this knowledge to solving numerical problems of everyday life.

3. To teach students basic concepts of number, mensuration and geometry, which may be a prerequisite for vocational programs.

Figure 1

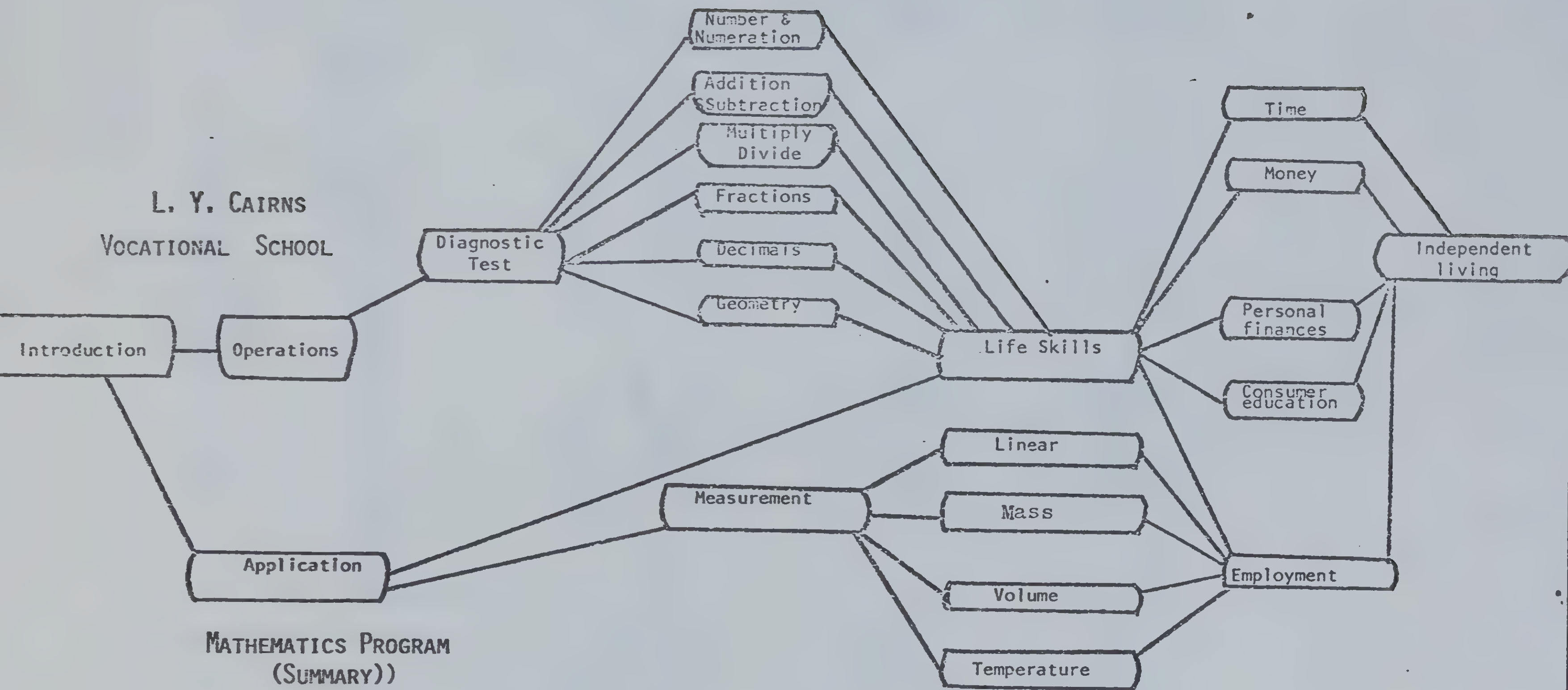
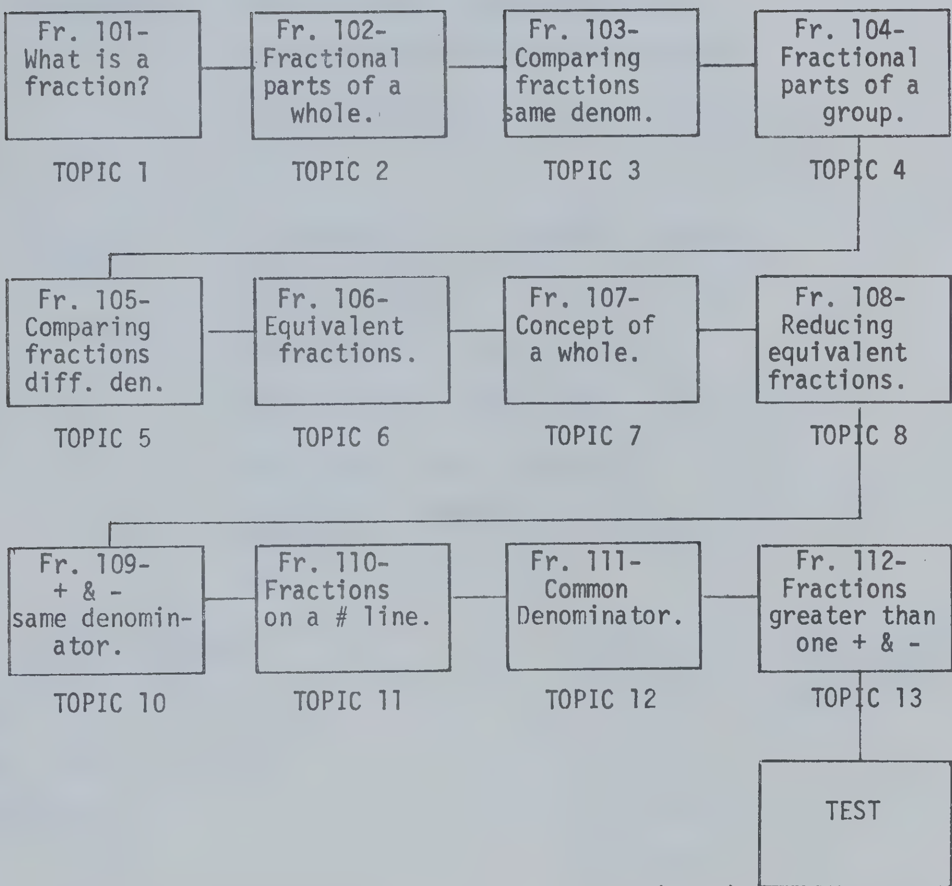


Figure 2
Summary Network



NOTE: The abbreviations relate to the network number code. Fr. is the prefix for topics related to common fractions.

Figure 3
Example of a concept network
Fractions

Topic 1. Network # Fr 101

What is a Fraction?

Objective. The student will understand that a fraction is part of a whole and that fractional parts of a whole are equal in size.

Content. An introduction to fractional numbers using the fraction 1/2 to illustrate the meaning of a fractional part. Concrete division of 1 whole into 2 equal parts. Use of symbol 1/2. Recognition of 1/2 of a whole as being 1 of 2 equal parts.

RESOURCE MATERIAL	Code #	Access Code #
Tape Milton Bradley Lesson 1	Fr 101-1	MB 1
Tape Computapes Fr 1	Fr 101-7	Fr 1
Worksheets	Fr 101-21	A 1
	Fr 101-22	A 2
Text M7 Lesson 21 p. 1 - 11	Fr 101-3	Lesson 21
Cycloteacher	Fr 101-4	Cyc Fr 1
Set (teacher made assignment	Fr 101-5	Set Fr 1
Film strip, tape, worksheet.	Fr 101-6	FS 260

Figure 4

Example of objectives and resource material

c. reinforcement and overlearning.

6. Organizes each unit of resource material to be used with a particular concept sequentially. Code with a retrieval number as in the example in Figure 5.

7. Using the sequence planned in step 3, organize several of the 'mini-networks' developed in step 6 into a network which will become the record sheet from which the student will take his assignments and which will act as a record of his progress through the program. An example is presented in Figure 6.

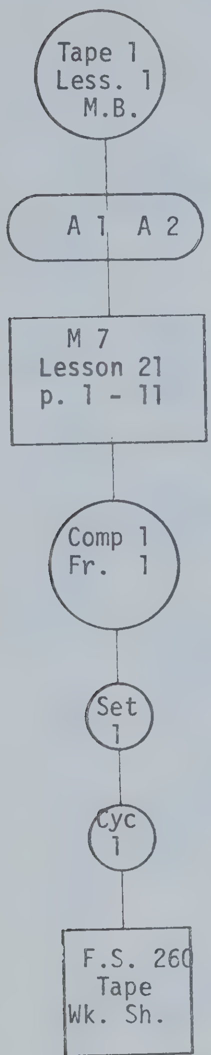
8. Develop diagnostic and evaluative instruments which will indicate a student's initial placement in the program and provide an evaluation of its effectiveness. The evaluative instrument developed is to be found in Appendix B.

It should be noted that the conventional flow chart basic symbols related to systems used in Hathaway's original project have not been adhered to. Different shapes indicate different types of resource material and are used merely to alert the teacher as to the type of resource material required. The key is presented in Figure 7. Similarly lines and arrows denote the path to be followed and not activities as in the original thesis.

3. The Present Network

The summary network (Figure 2) displays the main areas of concern. The section arising from 'OPERATIONS' is taught entirely in the maths area. The remaining areas, 'APPLICATIONS' and 'LIFE SKILLS' whilst being

Explanation of Symbols



Cassette tape and worksheet.
Milton Bradley program
Lesson 1.

Worksheets taken from a published program.

Alberta Correspondence School.
Modified 7 program.
Lesson 21.

Cassette tape and worksheet.
S.R.A. Computape program.
Fraction Lesson 1.

Teacher made set of problems.

Cycloteacher wheel. Teacher made assignment - for review.

Commercial filmstrip, teacher made worksheet. For review of concepts. Teacher made tape.

Figure 5
Example of a network program. Taken from the fraction network.
Topic - 'What is a fraction?'

NOTE: The abbreviations relate to the network number code. Fr. is the prefix for topics related to common fractions.

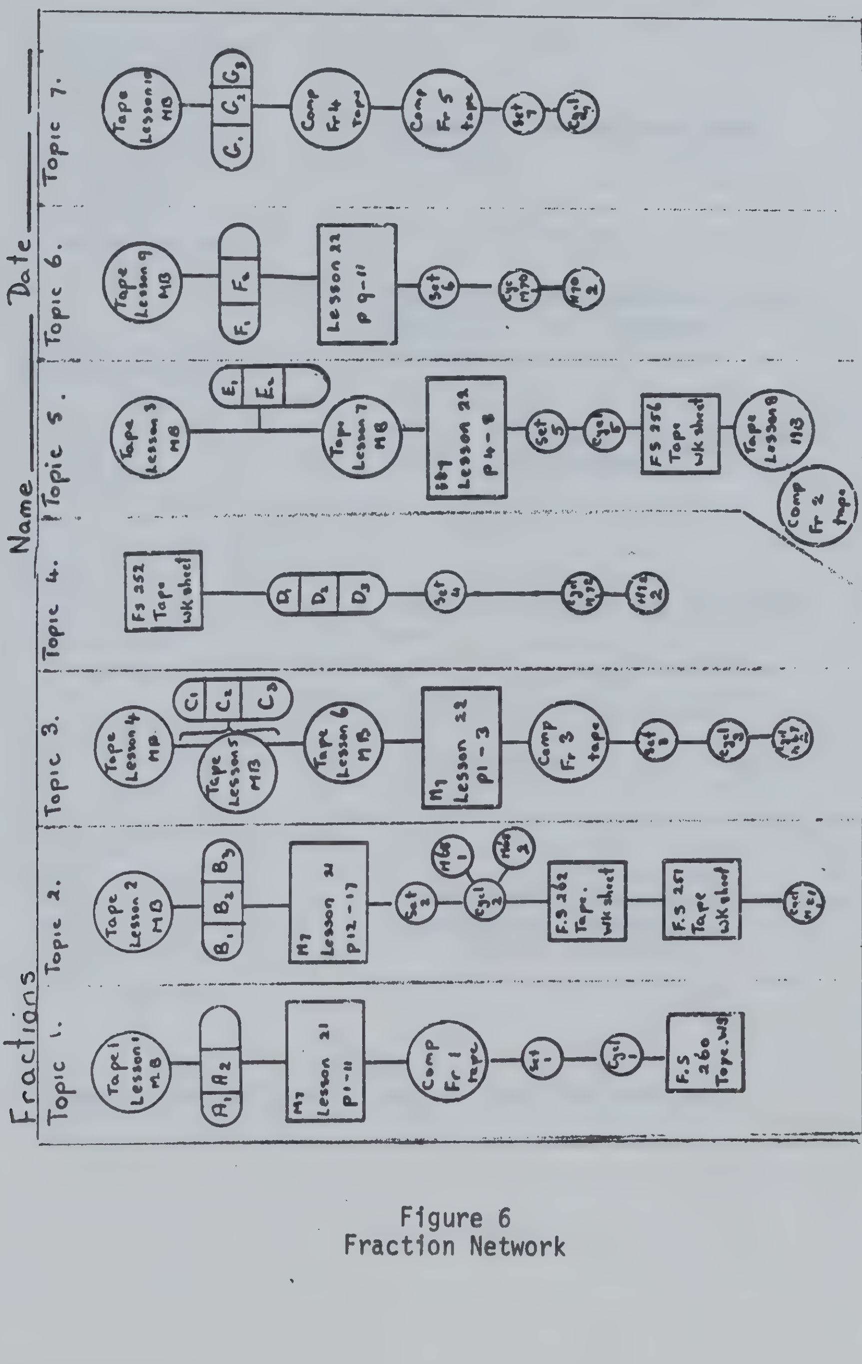
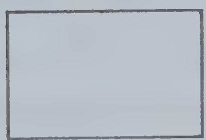


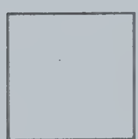
Figure 6
Fraction Network

Cassette tape and worksheet.



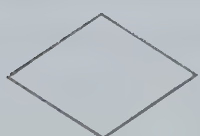
Alberta Correspondence School.
Modified 7 or 8 program.
Lesson.

Set of problems, made by teacher, or
Cyclo-teacher wheel.



Film strip, tape and worksheet.

Worksheets.



Problem solving worksheets. Tape
available if required.

Figure 7
Symbols used to denote type of resource material.

taught at an introductory level in the maths area, are becoming increasingly integrated with a 'living skills' or 'Human relations' program, whilst much of the measurement section is taught in a more meaningful way in the vocational areas of the school.

An attempt has been made to 'spiral' the curriculum, in the sense that two groups of networks exist for each of the areas related to 'OPERATIONS'. One at a lower level is concerned with the more simple concepts, whilst the second level revises the concepts of the first and proceeds to more difficult topics. For example, the first level in division goes as far as the division of 3 digits by 2 digits. More difficult division is not met with until the second level, which a student would not meet until he had completed the lower levels of fractions and decimals.

Content

The section related to 'OPERATIONS' is concerned mainly with those concepts usually found in a regular Grades 1 to 6 program. The stress however, is on functional arithmetic and for most students such topics as 'Bases other than ten' or more complex Roman Numerals are excluded. Geometry is mainly simple nomenclature and constructions.

The section related to 'Life Skills' at its lowest level is concerned with the most basic skills which would allow for independent life, e.g. small cash transactions, whilst for students capable of understanding topics such as simple Income Tax returns, are included. Much of this area is taught in small group situations.

Measurement includes both Metric and English systems as tools in shops are not yet converted. Much of this area has still to be developed.

Resource Materials - A detailed bibliography of Resource Materials, is to be found in Appendix A.

1. Texts

Parts of the Alberta Correspondence School Modified 7 and Modified 8 program is used as worksheet material. The program presents very simple concepts in a manner which young adolescents will accept without labelling the material 'babyish'. The format and print used is apparently sophisticated and the program is labelled M 7 or M 8, all of which reinforces the student's self-respect with regard to his abilities. Additionally, new concepts are well explained and for the students with a reading level of Grade 4+ much can be done independently with minimum of teacher help required.

For simplicity and convenience, the sequence of concepts used in this program coincides quite closely with the network sequence.

The Sullivan Programmed Mathematics is used for some students, particularly in the senior areas, (ages 16+) who may require further repetition and practice with elementary concepts. The text is self-correcting providing immediate feedback to the student.

A further text used in the living skills area is *Business and Consumer Maths by Conchie*. Tapes and worksheets have been prepared by the teachers to use in conjunction with this text, which in its published form is too difficult for many of the students.

2. Audio-visual Material

The hardware required for this type of material is contained in the Resource Room. About 25 students can be accommodated at any one time, in carrels, individual work stations or a listening centre. 'Software', e.g., cassette tapes, film strips, language master cards, etc., are filed in the same room along with a variety of worksheets coded according to the network. As far as possible all software materials are filed visually, for ease of accession. The room contains tape recorders, film strip viewers (both for individual and group use), slide projectors, cyclo teacher wheels, Language Master, Flash-x holders, and a projector for 'Controlled Reader' Material. (These last two items are a form of tachistoscope). Simple calculators are available in each classroom and senior students have access to an adding machine and a cash register.

(a) Commercially Produced Material

Commercially produced material has to be resequenced to fit into the network. Most do not contain sufficient practice material for the slow learning child, thus material from several programs may be used for the teaching of one particular concept.

Programs which have been used are as follows:

Cassette Tapes

1. Computapes - published by Science Research Associates.
2. Educational Sensory Programming - Basic Elementary Mathematics - Jones Boro, Arkansas.
3. Arithmetrics - published by Coronet Instructional Media.
4. Power Pac Maths - published by Imperial International Learning.

5. Merrill Skill Tapes - published by Bell & Howell.
6. Fraction Tapes - published by Milton Bradley.
7. Telling Time - published by Encyclopedia Brittanica.
8. Inches and Fractions, Centimetres and Decimals - published by Encyclopedia Brittanica.

A complete list of materials and publishers is appendixed. All programs have worksheets to accompany them and most are self-correcting.

Film Strips

A wide variety have been acquired. In order to facilitate their use and partly to compensate for low reading levels, it has been necessary to add a teacher made cassette and worksheet. A student response to each frame produces more effective learning. See Appendix for details of film strips.

(b) Teacher made Materials

An intrinsic part of the network is those rote learned skills of basic number facts. These have been broken into small units or 'learning packs'. Most of this material is teacher made and consists of the same number facts presented in a different media to alleviate the boredom of repetitious tasks. These media are:

1. Flash cards.
2. Write on slides. The fact on one, the answer on the next.
3. Language Master cards (Bell & Howell).
4. Flash-x (Educational Development Laboratory).
5. Cyclo teacher wheels (World Book Corporation).
6. Written test material.

By using blank cards for the commercial programs, the sequence of facts being taught may be kept constant.

All the material provides immediate feedback for the student as to the correctness of the response.

(c) Supplementary Materials

It is apparent that for some low achieving students much of the foregoing material is unsuitable, the following programs are available for these students.

1. Schoolhouse Series 1 and 2, Science Research Associates.
2. Maths Activities, Stott, published by Gage.

In the senior area, the application of maths to such areas as consumer education, pay roll deductions and other such life skill topics has necessitated the production of units by teachers. Units may be produced by the maths team or an individual teacher. They become part of a central pool and are used by all.

Problem solving units have been produced by using questions from a commercially produced text and recording the questions on tape for non-readers.

A variety of manipulative materials are available for teachers to use at their discretion, these include attribute blocks, number blocks, abacus, walk-on number lines, counting materials, etc.

Placement and Evaluation Materials

With the help of the Edmonton Public School Board Testing and Evaluation Department, a three level placement test has been devised,

based on the content of the curriculum. A copy is to be found in Appendix B. It consists of items that test the student's knowledge of numeration, place value, operations (computational skills) and problem solving skills that depend upon the student's ability to reason logically. By means of timed tests, the student's knowledge of rote number facts, e.g. multiplication tables, is also evaluated.

The Wide Range Achievement Test (Jastek & Jastek, 1965) is also administered on an annual basis, so that ongoing research may be planned and in order to provide a comparison grade level score for overall educational evaluation required by other institutions.

Organization

The school is organized by seven year level groupings based on chronological age. Within each year level are approximately six classes each containing from 12 to 15 students. These students remain together for academic lessons, but are regrouped in the vocational areas. An attempt is made to group students homogenously by reading comprehension level, based on Schonnell test scores, and also by a subjective assessment of social maturity. As a result the mathematical functioning of a class may vary widely.

Six teachers form the mathematics team, with one assigned as department head. Two of the six are responsible for the senior classes. Each teacher is responsible for instructing several classes and also for staffing the Resource Room.

On entry, a student will be given a placement test to determine at which point in the network he should start. His knowledge of rote-

learned number facts, e.g., multiplication tables, is also determined. At the conclusion of each school year, the student's network sheets are passed to the teacher who will teach him in the following year. In this way, continuous progress can be maintained from year to year.

Once placement is determined, either from the previous year's record or from the placement test, the requisite networks are stapled in each student's file folder. This is kept permanently in the classroom and is used by both teacher and student as a record of achievement and plan of assignments. Current assignments are kept in the folder, completed work is kept in a binder and filed in the classroom.

If the assignment is one that needs audio-visual equipment, the student will leave the classroom to work in the Resource Room under the supervision of the teacher there. This teacher using the network as a guide will assign the required material. Many students become competent at finding their own material.

If help is required with the assignment, either the classroom teacher or the Resource Room teacher will work with the student.

Upon completion of the assignment, it is corrected by either teacher, and further teaching given if necessary. If the required standard has been reached, the related 'bubble' in the network sheet is signed and dated. When rote memory skills are being learned a short written and oral test is given. Since several students may leave the classroom for the Resource Room, the classroom teacher is left with a sufficiently small number of students for individual instruction to be given as and when required. Other students may be working upon assign-

ments that can be completed in the classroom. Again completion is recorded with initialling and dating a 'bubble' on the network sheet.

As these networks sheets are the only record kept, administrative work for the teacher is kept to a minimum. They provide for both teacher and student a record of progress. The steady progress that can be seen is reinforcing to the student and helpful in discussions with parents as to progress being made. Dates enable the teacher to judge the speed of progress. Completed assignments and networks are filed into a binder kept in the classroom and the steady accumulation of work also has a reinforcing effect upon the students. Comparisons between one student and another are minimal, thus reducing feelings of failure and frustration.

At some point in the year, a teacher will move with his classes to a classroom designated as a 'Measurement Room'. This is set up with varying equipment and assignments dealing with the various aspects of measurement. Assignments will be carried out individually but much of the teaching is group instruction.

The foregoing description is applicable to the majority of the students but some are functioning at so low a level that this network does not provide for them. For such students, teachers will produce an individualized network that may include the SRA 'Schoolhouse' material or selected games and activities chosen from Stott's 'Maths Activities'. Instruction in the use of simple calculators helps to motivate older students.

Program Development

The six teachers involved in the maths team - who incidentally do

not team teach - meet weekly to discuss ongoing problems and to plan development or initiate modifications to the program. Professional development days and teacher preparation time are devoted to this task.

Each teacher in turn will take a major area, e.g., consumer education, and initiate the overall planning. Once different areas have been identified, each teacher will be responsible for developing a network for one area, compiling resource material and constructing record sheets. The total unit can then be coded, filed and is available for all to use. Modifications and revisions are made in the light of experience with the unit.

Classroom lesson preparation in the usual sense is minimal, which frees the teacher for the task of curriculum development. Much of the senior Life Skills' program is still to be developed as are some areas of measurement. Additionally, as the students appear to be covering the content far more quickly than previously, extensions are having to be made at the upper end of the program. Certain concepts which few students reached before, e.g., decimals and percents, are being studied by a growing number of students.

Most of the formal instruction carried out by the teacher is usually with individual students, although from time to time it is possible to teach a small group of students who have all reached the same point in their program at the same time. Total class instruction is confined to periods when reviews are being conducted or when a topic unrelated to the general network is being introduced. A unit on such topics as simple geometry or the use of the hand held calculator is an

example. It is found however, that the students diverge so quickly in their ability to deal with the new area, that total group instruction rapidly becomes impossible.

Subjective Evaluation

The content of this section of the study is derived from the informally expressed opinions of the six teachers involved in the program for the three years of the study. Weekly meetings and a close working relationship between the teachers appeared to eliminate the need for a formal questionnaire. Feedback from other teachers in the school derived from informal discussions with the students was helpful in ascertaining students' attitude to the program.

Most students appear to like mathematics better than they did before, and this is producing greater motivation to succeed. Requests from students for homework are frequent as are statements such as 'Math is my best subject'. Failure is kept to a minimum and since each student progresses at his own speed, frustration levels are lower. The built-in reinforcement of perceived progress (a binder filling with completed assignments, the progression from a green to a pink network sheet) is also of value. The students are aware of the sequential progression and many are motivated by it to work diligently.

The mechanization of the Resource Room adds interest to repetitious tasks and many students attending behavior is improved with isolation in a carrel. The use of headsets not only reduces extraneous stimuli but can be beneficial in improving listening skills.

In general work habits have improved and there seems to be less disruptive classroom behavior. Some indication of students' attitude to the individualized program is the opposition that occurs when a teacher wishes to change the regular routine in order to teach some unrelated unit to the class as a whole.

Although the view has been expressed that under this system the teacher is little more than a clerk, teachers working within it have not felt this way. Rather, they have seen it as a system that has enabled them to structure the learning situation in such a way that they can more competently handle the varied problems that arise. Whilst the content of the curriculum may be clearly specified, the methodology the teacher chooses to use in his teaching is of his own choice. Perhaps the fact that the maths team has stayed as an entity for over two years indicates their attitude towards the program.

One additional benefit from the structured program and clear indication of future assignments is that it minimizes the confusion that occurs when a regular teacher is absent.

In general, the feeling is that students are going further than they did previously and are making faster progress. Whether this is an accurate assessment awaits the findings of the objective evaluation, which is discussed in the remaining chapters.

IV. DESIGN AND PURPOSE OF THE STUDY

The problem of implementing a method of individualizing a mathematics curriculum with a large heterogenous population is investigated in this study. It is undertaken to determine whether a network approach to curriculum development is an effective and efficient method of providing basic elementary mathematics instruction to a large number of mentally handicapped students whose level of functioning and achievement in arithmetic vary widely.

The traditional method of classroom group instruction does not allow sufficiently for individual differences. With a network approach, much learning independent of the teacher may take place and greater emphasis can be placed upon individual needs and differences.

There exists at present no objective evidence that this method of individualization results in greater achievement in basic mathematical skills. This study attempts to provide such evidence.

The study was undertaken in a junior/senior high school which admits students who, because of severe learning problems related to intellectual impairment, have been designated as in need of special education. The school is part of the Public School System of a city in Alberta.

The experimental program in individualized instruction was compared with the traditional classroom approach that had previously been used in the school. The experimental approach was in use for one school

year (1975 - 1976) with the total school population, and with the junior and intermediate students (approximately two-thirds of the total) for a further year (1974 - 1975). Comparative test data were available for the total school population for the previous three years (1971 - 1974) during which period an eclectic approach to maths instruction was used with little continuity from year to year and with wide variations in the content and methodology used by teachers.

Design of the Study

Subjects

Five groups of subjects were identified, corresponding to year level within the school program. Each year level group is sub-divided according to the years in which they were in the traditional program and the years in which they were in the network program. The number of students in each type of program from 1971 to 1976 is presented in Table I.

The numbers do not represent the entire school population since by the end of the fifth year many students have left for employment or other training and those remaining are not typical of the school as a whole. They tend to be students with somewhat more severe mental handicaps, often coupled with physical or emotional problems, for whom it is more difficult to find employment. Additionally, the numbers remaining in years six and seven upon whom data exist from year one is too small to use for comparisons with previous years.

Originally data were collected on 395 subjects enrolled in the school between the period September, 1971 and June, 1976 on whom at

TABLE I

PLACEMENT OF SUBJECTS IN MATH PROGRAMS, 1971 - 1976

		Program in effect during school year				
Group	N	1971-1972 traditional	1972-1973 traditional	1973-1974 traditional	1974-1975 network	1975-1976 network
A	55	-	-	-	-	55
B	44	-	-	-	44	44
C	56	-	-	56	56	56
D	25	-	25	25	25	25
E	26	26	26	26	26	26

least one Wide Range Achievement Test score (W.R.A.T.) - Arithmetic Section, and a Full Scale Wechsler Intelligence score were available. There were 176 girls and 219 boys included in the population. The number 395 was reduced to 207 when children upon whom there were incomplete data were excluded from the study. Thus students entering the school in other than the first year of the school program and leaving prior to 1976 were not included. It should be noted that data presented relate only to those students retained in the study.

A description of the subjects by chronological age and I.Q. is presented in Table II. The I.Q. tests are normally administered by school psychologists prior to the student's admission to the school, or routinely during his stay in the school at approximately three to four year intervals. All testing is done by qualified psychologists or graduate university students in training.

Wechsler Intelligence Tests were used to measure I.Q. The Full Scale score only is used. Prior to June, 1974 the Wechsler Intelligence Scale for Children (W.I.S.C.) was used for subjects below the age of 16. After that date the Revised Wechsler Intelligence Scale for Children was used. For subjects over 16 the Wechsler Adult Intelligence Scale (W.A.I.S.) was used. Mean Full Scale scores from both W.A.I.S. and W.I.S.C. were treated as one group of I.Q. scores.

One of the questions in the study required the subjects to be grouped by 'low' and 'high' I.Q. A division was thus made into those students with an I.Q. of 71 and above and those with an I.Q. of 70 and below. A description of subjects in the two groups by chronological age and I.Q. is presented in Table III.

TABLE II

DESCRIPTION OF SUBJECTS BY AGE AND INTELLIGENCE QUOTIENT

		Chronological age as of Sept. 1st., 1975 (months)			Wechsler Full Scale Intelligence Score		
Group	N	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range
A	55	155.60	4.81	146-172	71.11	7.56	48-87
B	44	167.50	5.35	156-183	72.75	9.10	45-93
C	56	177.34	6.13	161-192	70.43	9.70	43-88
D	25	190.16	6.00	181-203	74.64	8.42	52-87
E	26	200.12	7.94	189-224	71.65	9.20	46-85

TABLE III

DESCRIPTION OF SUBJECTS SUB-DIVIDED INTO HIGH AND LOW I.Q. GROUPS, BY CHRONOLOGICAL AGE AND INTELLIGENCE QUOTIENTS

		Chronological age as of Sept. 1st, 1975 (months)			Wechsler Full Scale Intelligence Score		
Group	N	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range
A High	31	156.39	5.18	146-172	76.23	4.38	71 - 87
A Low	24	154.63	4.19	149-164	64.50	5.31	48 - 70
B High	28	166.86	4.86	156-173	78.04	4.57	71 - 93
B Low	16	168.63	6.11	148-183	63.50	7.51	45 - 70
C High	32	176.66	5.78	163-192	76.94	3.90	71 - 88
C Low	24	178.25	6.58	161-191	61.75	8.17	43 - 70
D High	16	189.56	6.08	181-193	79.54	5.12	71 - 87
D Low	9	191.22	6.08	184-203	66.11	5.95	52 - 70
E High	15	198.33	6.18	189-211	77.73	5.19	71 - 85
E Low	11	202.55	9.64	191-224	63.36	6.53	46 - 70

Data Collection

Grade level scores in arithmetic were available for each school year whilst the child was in school. They were obtained from routine administration of the arithmetic section of the Wide Range Achievement Test (Jastek & Jastek, 1965) which was carried out as a group test by classroom teachers in the spring of each year. Care was taken that the time of day and other such factors were considered to ensure that as optimal an achievement level as possible was reached. Additionally, routine administration was carried out in September, 1974 and 1975 with students entering year one at those times to study in depth those subjects whose entire program would be on the network curriculum.

The average level of achievement in arithmetic for each group of children is presented in Table IV. The average level of achievement in arithmetic for each group of students sub-divided into high and low I.Q. groups is presented in Table V. The W.R.A.T. surveys arithmetic computational skills from kindergarten level through basic operations of addition, subtraction etc., to the high school level. The W.R.A.T. does not test reasoning ability. It is administered as a group test without a time limit. Because of the physical limitations of some students, a large print version of the test was used for all students. The mean, standard deviation and range for each group in the study are presented.

Purpose of the Study

The data were considered to determine the following:

1. Is there any significant difference between the levels of achievement of the children in the two types of programs as measured by average

TABLE IV

DESCRIPTION OF SUBJECTS BY LEVEL OF ARITHMETIC ACHIEVEMENT
ATTAINED AT THE CONCLUSION OF EACH SCHOOL YEAR

		1971-1972			1972-1973			1973-1974			1974-1975			1975-1976		
Group	N	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range
A	55	-	-	-	-	-	-	-	-	-	-	-	-	3.93	.78	2.6-5.3
B	44	-	-	-	-	-	-	-	-	-	4.07	.80	2.6-5.9	4.12	.94	2.2-6.3
C	56	-	-	-	-	-	-	3.61	.84	1.0-5.0	4.06	1.08	1.2-6.3	4.37	1.10	1.9-6.3
D	25	-	-	-	3.82	.64	2.4-5.2	4.08	.67	2.8-5.2	4.52	.93	2.8-6.7	4.98	1.16	2.6-7.6
E	26	3.57	.74	1.4-4.7	3.75	.79	0.8-4.7	3.84	.75	1.8-5.3	4.34	1.05	1.0-6.1	4.90	.82	2.6-6.3

TABLE V

DESCRIPTION OF SUBJECTS SUB-DIVIDED INTO HIGH AND LOW I.Q. GROUPS, BY LEVEL OF ARITHMETIC ACHIEVEMENT AT THE CONCLUSION OF EACH SCHOOL YEAR

		1971 - 1972			1972 - 1973			1973 - 1974			1974 - 1975			1975 - 1976		
Group	N	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range
A High	31	-	-	-	-	-	-	-	-	-	-	-	-	4.30	.67	3.2-6.1
A Low	24	-	-	-	-	-	-	-	-	-	-	-	-	3.47	.67	2.4-4.7
B High	28	-	-	-	-	-	-	-	-	-	4.35	.58	3.2-5.5	4.48	.53	3.2-5.5
B Low	16	-	-	-	-	-	-	-	-	-	3.57	.90	2.6-5.9	3.49	1.16	2.2-6.3
C High	32	-	-	-	-	-	-	3.90	.72	2.6-5.0	4.35	.95	2.8-6.5	4.73	1.00	2.6-6.3
C Low	24	-	-	-	-	-	-	3.29	.90	1.0-4.7	3.68	1.14	1.2-5.5	3.89	1.06	1.9-5.7
D High	16	-	-	-	4.01	.59	3.0-5.2	4.30	.67	2.8-5.2	4.90	.88	3.0-6.7	5.25	1.26	2.6-7.6
D Low	9	-	-	-	3.49	.62	2.4-4.2	3.69	.46	3.0-4.5	3.83	.59	2.8-4.7	4.50	.82	2.8-5.2
E High	15	3.77	.51	2.8-4.5	3.83	.49	2.8-4.5	3.95	.58	3.0-4.7	4.51	.76	3.0-5.7	4.97	.68	3.2-6.1
E Low	11	3.31	.92	1.4-4.7	3.64	1.11	.8-4.7	3.69	.95	1.8-5.3	4.10	1.36	1.0-6.1	4.81	1.01	2.6-6.3

number of months' gain made by the children at the same year of the two programs?

2. Does the level of I.Q. affect the level of achievement to a similar degree in both programs, with again, the level of achievement being measured by average number of months' gain by high and low I.Q. groups made by children at the same year of the two programs?

Data Analysis

Two types of analyses were completed.

1. Using gain scores calculated by using mean achievement scores obtained at the end of the preceding year as pretest scores and mean achievement scores obtained at the end of the year under consideration as post-test scores, comparisons were made between

   a. The four groups B, C, D and E during their second year on the programs (B and C network, D and E traditional).

   b. The three groups C, D and E during their third year (C and D network, E traditional).

   A Scheffé comparison of observed means was used to determine if significant differences existed between the groups.

   For the following two sections the children in each group were subdivided into two groups, 'High I.Q.' and 'Low I.Q.'. For the purposes of this analysis, I.Q. range 70 and below is defined as 'low' while I.Q. scores of 71 and above are defined as 'high'. A description of the groups' subdivisions by chronological age and I.Q. is given in Table III. The purpose of these analyses was to answer question 2,

namely whether the level of I.Q. affected the level of achievement to a similar degree in both the traditional and network programs.

2. Using gain scores calculated as previously described, comparisons were made between

a. The four 'high I.Q.' groups B, C, D and E during their second year on the programs (B and C network, D and E traditional).

b. The four 'low I.Q.' groups B, C, D and E during their second year on the programs (B and C network, D and E traditional).

c. The three 'high I.Q.' groups C, D and E during their third year (C and D network, E traditional).

d. The three 'low I.Q.' groups C, D and E during their third year (C and D network, E traditional).

In each case a Scheffé comparison of observed means was used to determine if significant differences existed between the groups.

Definitions

a. Mentally handicapped. - Those students who, because of low intellectual functioning, are unable to profit from the programs offered in the regular school system. The I.Q. range is from approximately I.Q. 50 to I.Q. 85.

b. Arithmetical operations. - Those computational skills related to addition, subtraction, multiplication and division, both with whole and fractional numbers.

c. Arithmetic applications. - Logical reasoning skills combined with computational skills to solve arithmetic problems.

d. Network curriculum. - A modification of systems analysis techniques used in industry to provide for the educator an overall picture of the total curriculum, that is, at the same time a composite of its component parts.

e. Network. - A record sheet which indicates the sequential ordering of assignments which a student will complete as he covers a particular topic.

Limitations

a. Changes in school personnel and school organization may have produced a more effective overall learning climate which has played a role in improving arithmetic achievement. The teacher variable could not be controlled.

b. Because the network program has been in effect for only two years, the Hawthorne or novelty effect may be working to artificially improve network scores; only a program in effect for at least five years would make it possible to measure the constancy of arithmetic gains over time.

c. Only those parts of the curriculum that deal with the acquisition of arithmetical computational skills has been evaluated. This is a necessary but not sufficient pre-requisite for mathematical competence.

Assumptions

The following assumptions have been made:

a. Evidence from research has shown that intelligence as measured by I.Q. tests bears a relationship to the ability to acquire arithmetic computational skills. The variations that occur in the arithmetic abilities of normal children indicate that additional factors influence the learning of arithmetic. These factors are assumed to be acting in a uniform manner across the groups of students examined in the study.

b. That the subjects are sufficiently similar at each group level to make the comparisons between the groups valid.

V. RESULTS

This section of the study is an examination of the results of the data analysis described in the previous chapter, with a view to facilitating an enquiry into the relative merits of the network approach to teaching mentally retarded adolescents as compared with a traditional approach.

Five groups of subjects were identified. Each group consisted of students who entered year one of the school program at the same time, in one of the years 1971 to 1975.

From September, 1971 to June, 1974 (three school years) a traditional arithmetic program was used for all students, any data obtained during this period are classified as 'traditional'. From September, 1974 to June, 1976 a network program was in effect and any data collected during this period are classified as 'network'.

By making comparisons of mean gain scores between the two programs, an objective evaluation of the network approach to teaching arithmetic to mentally retarded adolescents has been carried out. In addition, by dividing the subjects into 'high' and 'low' I.Q. groups, it is hoped to identify whether the program is more effective with a particular group of students.

The following discussion is divided into two major areas.

1. Analyses in which the total groups are used for comparisons. Gain scores made either in the second or third year of the

traditional program are compared with gain scores made during the comparable year of the network program.

2. Analyses in which each group is subdivided into 'high I.Q.' (I.Q. 71 and above) and 'low I.Q.'. (I.Q 70 and below). Gain scores made either in the second or third year of the traditional program by the high I.Q. groups are compared with gain scores made by the high I.Q. groups during the comparable year of the network program.

In a similar manner, gain scores made by the 'low I.Q.' groups in either the second or third year of the traditional program are compared with gain scores made by the 'low I.Q.' groups during the comparable year of the network program. In all cases in which statistical comparisons between groups were made, Scheffé tests of multiple comparisons of observed means were used to determine if the differences between groups were significant. Ferguson (1971) suggests that because of the rigorous nature of the Scheffé procedure, a 0.1 probability level may be employed. This is the criterion that has been adopted as statistically significant in this discussion.

The first part of the data analysis was concerned with gains made by students in each of the second and third years in which they were in either of the two programs. These are presented in Table VI. The results of the statistical analysis carried out on the mean gain scores for the second and third years of the two programs are presented in Table VII. There were no significant differences in the gains made by students in their second year of the network program when compared

with students in their second year of the traditional program. The significant difference that occurs between groups B and C (B mean .05, C mean .45) is between groups both on the network program. No significant differences were noted on the gains made during year three between any of the groups.

The gains made by students sub-divided into high and low I.Q. groups, during the second and third years of the two programs, were analyzed for statistical significance. The data are presented in Table VIII. It was hoped that from this data, some inferences could be drawn as to the relative effectiveness of the network program with students of greater or less intellectual ability.

When mean gain scores of the 'high' I.Q. groups on the network program during year two were compared with mean gain scores of the 'high' I.Q. groups on the second year of the traditional program (Table IX), a significant difference was noted between groups C and. (C mean .45, E mean .07). Group C was on the network program during this year, while group E received traditional instruction. A significant difference was also found between groups B and C (B mean .12, C mean .45) but both these groups were on the network program.

The comparison of mean gain scores for 'high' I.Q. groups in their third year is also presented in Table IX. No significant differences were observed.

A similar comparison of mean gain scores for 'low I.Q.' groups in the second and third years of the two programs was made (Table X). No significant differences were observed between groups that were on differ-

TABLE VI

COMPARISON OF MEAN ARITHMETIC GAINS DURING YEARS II AND III OF THE TRADITIONAL AND NETWORK PROGRAMS

	Group	N		Traditional $\bar{X}$	Traditional S.D.	Traditional Range	Network $\bar{X}$	Network S.D.	Network Range
	B	44	pre-test				4.07		
			post-test				4.12		
			gain	-	-	-	.05	.42	- .6 to .8
YEAR II	C	56	pre-test				3.61		
			post-test				4.06		
			gain	-	-	-	.45	.67	-1.0 to 1.8
	D	25	pre-test	3.82					
			post-test	4.08					
			gain	.26	.51	- .6 to 1.2	-	-	-
	E	26	pre-test	3.57					
			post-test	3.75					
			gain	.18	.42	-1.0 to 1.0	-	-	-
	C	56	pre-test				4.06		
			post-test				4.37		
			gain	-	-	-	.31	.67	-1.1 to 2.1
YEAR III	D	25	pre-test				4.08		
			post-test				4.52		
			gain	-	-	-	.44	.52	- .4 to 1.5
	E	26	pre-test	3.75					
			post-test	3.84					
			gain	.09	.49	- .7 to 1.1	-	-	-

TABLE VII

PROBABILITY MATRIX FOR SCHEFFÉ MULTIPLE COMPARISON OF MEANS FOR GAIN SCORES MADE DURING YEAR II AND YEAR III OF THE TRADITIONAL AND NETWORK PROGRAMS

	Group	B	C	D	E
YEAR II	B	1.0000	.0043**	.4947	.8251
	C	.0043**	1.0000	.5305	.2041
	D	.4947	.5305	1.0000	.9597
	E	.8251	.2041	.9597	1.0000
YEAR III	C		1.0000	.6556	.3339
	D		.6556	1.0000	.1269
	E		.3339	.1269	1.0000

** significant, $P < 0.10$

TABLE VIII

COMPARISON OF MEAN ARITHMETIC GAINS DURING YEARS II AND III OF THE TRADITIONAL AND NETWORK PROGRAMS FOR FOUR GROUPS OF SUBJECTS SUB-DIVIDED INTO HIGH AND LOW I.Q. GROUPS

			YEAR II						YEAR III					
			Traditional			Network			Traditional			Network		
Group	N		$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range
B High	28	pre-test				4.35								
		post-test				4.48								
		gain	-	-	-	.12	.40	- .6 to .8	-	-	-	-	-	-
B Low	16	pre-test				3.49								
		post-test				3.57								
		gain	-	-	-	.08	.44	- .6 to .7	-	-	-	-	-	-
C High	32	pre-test				3.90						4.35		
		post-test				4.35						4.72		
		gain	-	-	-	.45	.71	- .6 to 1.8	-	-	-	.37	.70	-1.1 to 2.1
C Low	24	pre-test				3.29						3.68		
		post-test				3.68						3.89		
		gain	-	-	-	.39	.62	- .3 to 1.6	-	-	-	.21	.63	-1.0 to 1.4
D High	16	pre-test	4.01									4.30		
		post-test	4.30									4.90		
		gain	.29	.50	- .5 to 1.1	-	-	-	-	-	-	.60	.54	- .3 to 1.5
D Low	9	pre-test	3.49									3.69		
		post-test	3.69									3.83		
		gain	.20	.55	- .6 to 1.2	-	-	-	-	-	-	.14	.35	- .4 to .6
E High	15	pre-test	3.77						3.83					
		post-test	3.83						3.95					
		gain	.07	.38	-1.0 to .9	-	-	-	.12	.47	- .6 to 1.1	-	-	-
E Low	11	pre-test	3.31						3.64					
		post-test	3.64						3.69					
		gain	.33	.46	- .6 to 1.0	-	-	-	.05	.53	- .7 to 1.0	-	-	-

TABLE IX

PROBABILITY MATRIX FOR SCHEFFÉ MULTIPLE COMPARISON OF MEANS FOR GAIN SCORES MADE BY THE HIGH I.Q. GROUPS DURING YEAR II AND YEAR III OF THE TRADITIONAL AND NETWORK PROGRAMS

	Group	B	C	D	E
YEAR II	B	1.0000	.0686**	.7958	.9919
	C	.0686**	1.0000	.6647	.0945**
	D	.7958	.6647	1.0000	.7178
	E	.9919	.0945**	.7178	1.0000
YEAR III	C		1.0000	.4833	.4287
	D		.4833	1.0000	.1027
	E		.4287	.1027	1.0000

** significant, $P < .10$

ent programs but in year two a significant difference existed between groups B and C both of whom received network instruction (B mean .08, C mean .39).

A comparison of the 'low' I.Q. groups in year three also produced no significant differences (Table X).

TABLE X

PROBABILITY MATRIX FOR SCHEFFÉ MULTIPLE COMPARISON OF MEANS FOR GAIN SCORES MADE BY THE LOW I.Q. GROUPS DURING YEAR II AND YEAR III OF THE TRADITIONAL AND NETWORK PROGRAMS

	Group	B	C	D	E
YEAR II	B	1.0000	.0803**	.6820	.3120
	C	.0803**	1.0000	.8500	.9924
	D	.6820	.8500	1.0000	.9639
	E	.3120	.9924	.9639	1.0000
YEAR III	C		1.0000	.9533	.7444
	D		.9533	1.0000	.9388
	E		.7444	.9388	1.0000

** significant P $<$.10

VI. CONCLUSIONS

This study was carried out in order to determine whether an experimental network curriculum designed to provide an individualized approach to teaching arithmetic to mentally retarded adolescent students, was in fact more effective than the traditional program which had previously been used.

The network approach had been in use for two years prior to the study. Subjectively, the team of six teachers involved in the program felt that it allowed them to deal more effectively with students on an individual basis, gave rise to behavior more compatible with learning and that students were progressing further, faster.

It was considered that the program should be examined in the light of objective data available in the form of Wide Range Achievement Scores for the two years during which the network had been in use and for the previous three years during which a traditional approach to arithmetic had been used. By comparing gains made by students on the two programs, it was hoped to determine whether in fact the network program was as effective as it seemed.

As a corollary to this, it was felt that the network program should be evaluated in terms of its effectiveness with students of relatively higher or lower I.Q. This was done by regrouping the students at each year level into sub-groups of higher or lower I.Q. and repeating the comparisons described in the previous paragraph.

From an examination of Table VI which presents data of mean arithmetic gains made by four groups of students during years two and three there is some evidence that the network program is more effective in producing greater gains, the three greatest gains were made by groups on the network program. (Group C in years two and three, group D in year three).

When the mean gain scores of the four groups of students sub-divided into high and low I.Q. groups are considered (Table VIII), it may be seen that in the 'high' I.Q. groups, again the three greatest gains were made by groups on the network program (Group C in years two and three, group D in year three).

For the low I.Q. groups, there is little evidence that either program is more effective in terms of gains made (Table VIII). On the other hand, there is no evidence the network program is less effective than the traditional program for this group. Statistical analyses of the data were carried out using Scheffé multiple comparison of means test. The $P < 0.1$ level of significance was used.

The data were analyzed in terms of the mean gains in achievement scores made by comparable groups of students in both the network and traditional program. Initially the comparisons were made between the groups considered as a whole. This was followed by making comparisons of the groups sub-divided into high and low I.Q.

Using data obtained at the end of the first year as pre-test scores and data obtained at the end of the second year as post-test scores, the mean gains for year two were calculated and comparisons made

between groups on the network program and groups on the traditional program. No significant differences between the two programs were noted (Table VII - Year II). A comparison of the gains made during year three also demonstrated no significant difference between the groups (Table VII - Year III).

There thus appears to be no evidence that the network program produced greater gains in mean achievement scores than did the traditional program, when the total group using the network program is compared with the total group using the traditional program.

Comparisons of mean gain scores between groups of students of relatively higher I.Q.'s on the traditional program and those on the network program were made. Table IX - Year II shows one significant difference occurring between one group on the traditional program and one group on the network program, during the second year of the program.

A comparison of gains made by the high I.Q. groups during the third year of the programs yielded no significant differences (Table IX - Year III).

There were six comparisons of mean gains on the traditional program with mean gains on the network program for students of relatively higher I.Q. Of these six comparisons, in only one was the difference between the group on the network program and the group on the traditional program found to be significant.

It thus appears that there is minimal evidence that the network program is more successful than the traditional program in producing greater gains in mean achievement scores with students of relatively

high I.Q.

Comparisons of gain scores made by students in the low I.Q. groups on the traditional program with similar students on the network program, for both the second and third years of the two programs, yielded no significant differences between the groups (Table X). The network program and the traditional program appear to have similar effects on mean gains in achievement scores with the lower I.Q. student.

In the light of the foregoing material, it is now possible to review the purpose of the study as stated in Chapter IV and answer the questions posed.

Question 1

Is there any significant differences between the levels of achievement of the children in the two types of programs (traditional and network) as measured by average number of months' gain made by children at the same year of the two programs?

There was no evidence to suggest that significant differences existed between the groups on the two types of programs in terms of the number of months' gain made by each group at comparable points in their program.

Question 2

Does the level of I.Q. affect the level of achievement to a similar degree in both programs, with the level of achievement being measured by average number of months' gain by high and low I.Q. groups, made by children at the same year of the two programs.

There appears to be only minimal evidence of any difference between the traditional and network programs. In the high I.Q. groups, from six comparisons made, one showed a significant difference between the network and the traditional program, with the network group having the greater mean gain. With the low I.Q. groups, no significant differences in mean gain scores were observed.

Summary and Recommendations

The conclusion that may be drawn from the statistical evidence is that the network program, designed to cater for the individual needs of the adolescent mentally retarded student in learning arithmetic, is at least as effective as the traditional program that it replaced. There is some objective evidence that it is more effective in teaching computational skills than the traditional program with students of relatively higher I.Q.

This, combined with the subjective feelings of teachers concerning less tangible benefits that the network system brings, namely greater teacher and student satisfaction, would suggest that the network program should be continued with modifications for the majority of the students.

The study showed however, that for students in the lower range of intelligence the network program was of doubtful value. This suggests that the network program in its present form should only be used for students near or above the mean I.Q. for students registered in the school program, (mean I.Q., approximately 70) unless the student appears to be particularly competent in arithmetic.

At the lower end of the educable mentally retarded range the network program in its present form does not appear to be any more effective in teaching arithmetic computational skills, than the traditional program it replaced.

This may be due to the fact that it is highly probable that these students have not reached the stage in the development of their cognitive processes that allows them to deal with the logical thought processes that are required to deal with number in an abstract way.

In addition, the network program requires a moderate amount of initiative on the part of the student to work independently without constant direction from the teacher. This may be a skill which the child of low intelligence has not or may not be able to develop.

If these assumptions are correct, then it is apparent that the whole content of the arithmetic curriculum for these students must be reconsidered. In an age of pocket calculators, perhaps the mathematics curriculum for these students should consist solely of those life skills, such as money, time and measurement needed if independent living is a real goal. The only alternative appears to be a major thrust of research to determine if the child in the lower I.Q. range can be accelerated in those cognitive skills which appear necessary for the acquisition of number concepts. In addition, the research would have to determine what changes in teaching methods and curriculum content are necessary to bring about a more rapid development of cognitive skills.

There is a growing tendency for educators to believe that the atypical child, should not be segregated from his peers. The relative

success of the network program described may perhaps suggest that this type of program could, with modifications, allow the retarded child in the upper I.Q. range to be integrated into the mainstream of education.

The network curriculum is not a finished product. It will only retain its vitality if it is continuously revised, updated, reviewed and evaluated. More importantly, it will only retain its effectiveness as long as it is perceived by teachers to be effective, and it may well be that any measure of success that this study has shown it to possess is due in large part to the teachers involved.

This study was limited in that it measured arithmetic achievement solely in terms of computational skills. Mathematics is an area which lends itself to research into the development of cognitive processes, an area which was not assessed by this study, but which is one of the objectives of the network program.

Further research in this area could perhaps utilize data which is gradually being acquired concerning the methods which are proving successful with average children for the teaching of problem solving skills which is a major objective in the mathematics curriculum for all children. Further research in this area could perhaps utilize data which is gradually being acquired of the problem solving skills of the students involved in this program.

There is a need for suitable testing and teaching material to be developed which could measure cognitive development in Piagetian terms, and which possessed a format that could be used with the sophisticated adolescent student.

Once such basic research had been carried out, it would allow teachers in the field to develop mathematics programs that could enhance cognitive development, in a logical sequential form, in preference to the empirical process which is currently used in curriculum planning for the mentally retarded child.

Observation suggests that changes other than the ability to achieve in mathematics may be occurring as a result of the program. These include such areas as self concept, social maturity and attitude. Further modification and evaluation of the program should include the use of instruments to measure these changes.

In summary, future development and evaluation of the program should involve greater emphasis upon mathematics content other than computational skills, in particular, problem solving skills need to be stressed.

There is also a need to evaluate changes occurring in cognitive development, in self concept, in social maturity and in attitude, for, in the final analysis, these are of greater importance in determining the quality of the retarded student's adult life, than his ability to perform in arithmetic.

BIBLIOGRAPHY

ARMSTRONG, J. R. 'The relationship of maths curriculum innovation, presented through two methods and effect upon achievement as a function of learner ability'. Wisconsin University. Madison. April, 1968.

ARMSTRONG, J. R. 'Mathematics Curriculum innovation and evaluation for educable mentally retarded'. Wisconsin University. 1969.

BENSBURG, G. L. 'The relation of academic achievement of mental defectives to mental age, sex, institutionalization and etiology'. *American Journal of Mental Deficiency*. 1953. 58: 327-330.

BIJOU, S., BIRNBRAUER, J., KIDDER, J. and TAGUE, C. 'Programmed Instruction as an approach to the teaching of reading, writing and arithmetic to retarded children'. *Psychological Record*. 1966. 16: 505-522.

BLACKMAN, L. and CAPOBIANCO, R. 'An evaluation of programmed instruction with the mentally retarded, utilizing teaching machines'. *American Journal of Mental Deficiency*. 1965. 70: 262-269.

BLACKMAN, L. 'The dimensions of a science of special education'. *Mental Retardation*. 1967. 5: 4: 7-11.

BLATT, B. 'The physical personality and academic status of children who are mentally retarded attending special classes as compared with children who are mentally retarded attending regular classes'. *American Journal of Mental Deficiency*. 1958. 62: 810-818.

BOWER, N. 'A comparison of arithmetic competencies, by mentally retarded and normal children'. Unpublished master's thesis. University of Missouri. 1970. Cited in CONNOLLY, A. J. 'Research in mathematics education and the mentally retarded'. *Arithmetic Teacher*. 1973. 20: 491-497.

BRADFIELD, R., BROWN, J., KAPLAN, P., RICHERT, E. and STANNERT, R. 'The special child in the regular classroom'. *Exceptional Children*. 1973. 39: 384-390.

CALLAHAN, J., JACOBSON, R. 'An experiment with retarded children and Cuisenaire rods'. *Arithmetic Teacher*. 1967. 14: 10-13.

CAWLEY, J. F., GOODMAN, J. O. 'Interrelation among mental abilities, language arts and arithmetic with the mentally handicapped'. *Arithmetic Teacher*. 1968. 15: 631-636.

CAWLEY, J. F., VITELLO, S. J. 'Model for arithmetical programming for handicapped children'. *Exceptional Children*. 1972. 39: 101 - 110.

CONNOLLY, A. J. 'Research in mathematics education and the mentally retarded'. *Arithmetic Teacher*. 1973. 20: 491 - 497.

CRUIKSHANK, W. M. 'Arithmetic ability of mentally retarded children: Ability to differentiate extraneous material from needed arithmetic facts'. *Journal of Educational Research*. 1948. 42: 161 - 170 (a).

CRUIKSHANK, W. M. 'Arithmetic ability of mentally retarded children: Understanding arithmetic processes'. *Journal of Educational Research*. 1948. 42: 279 - 288 (b).

CRUIKSHANK, W. M. 'Arithmetic work habits of mentally retarded boys'. *American Journal of Mental Deficiency*. 1948. 52: 318 - 330 (c).

DAS, J. P. 'Patterns of cognitive ability in non retarded and retarded children'. *American Journal of Mental Deficiency*. 1972. 77: 1: 6 - 12.

DEVENNEY, W. School Mathematics Study Group. Programs for low achieving Junior High school students. The Slow learner and Mathematics. National Council of Teachers of Mathematics 35th Year Book. 1972.

DIENES, Z. P. 'The growth of mathematical concepts in children through experience'. *Educational Research*. 1952. 11:1, 9 - 28.

DUNN, L. M. 'A comparison of the reading processes of mentally retarded boys of the same mental age'. Monographs of the Society for Research in Child Development. 19: (1) 1954.

ELLENBOGEN, M. L. A. 'A comparative study of some aspects of academic and social adjustment of two groups of mentally retarded children in special classes and in regular grades'. Dissertation Abstracts. 1957. 17, 2497.

ELLIS, N. R. 'The stimulus trace and behavioural inadequacy'. In ELLIS, N. R. (Ed.). Handbook of mental deficiency. New York: McGraw Hill. 1963. p. 134 - 158.

ENGLEMANN, S. and BRUNER, E. C. Distar: An instructional system. Chicago: Science Resarch Associates. 1969.

ENGLEMANN, S. and CARMINE, D. 'Distar' Arithmetic. Chicago: Science Research Associates. 1969.

FLETCHER, H. Mathematics for Schools. London: Addison Wesley. 1971.

GOLDSTEIN, H., MOSS, J. and JORDAN, L. 'The efficacy of special class training on the development of mentally retarded children'. U.S. Department of Health, Education and Welfare. Office of Education. Cooperative Researcy project #619. Urbana: Institute for Research on Exceptional Children. University of Illinois. 1965.

HARING, N. C., MADDOX, L. and KRUG, D. Investigation of systematic instructional procedures to facilitate academic achievement in mentally retarded disadvantaged children. Experimental Education Unit. University of Washington. 1971. #572167.

HATHAWAY, W. E. 'The network based approach to curriculum development for vocational programs'. Unpublished master of education thesis. University of Alberta. 1970.

HATHAWAY, W. E. 'A network based approach to curriculum development'. Edmonton. Author. 1971.

HATHAWAY, W. E. 'A feasibility study of the network based approach to curriculum development'. Unpublished doctoral dissertation. University of Alberta. 1975.

HEWETT, F. M. 'Educational engineering with emotionally disturbed children'. *Exceptional Children.* 1967. 4: 459 - 467.

HOOD, H. 'An experimental study of Piaget's theory of development of number in children'. *British Journal of Psychology.* 1962. 53: 273 - 286.

IRVINE, A., KUPCHENKO, E. 'Mathematics network'. In Research Bulletin. Edmonton Public Schools System. Edmonton, Alberta. 1973.

IRVINE, A., KUPCHENKO, E. and McELROY, M. 'Mathematics and Communication skills network'. In Research Bulletin. Edmonton Public Schools System. Edmonton, Alberta. 1974.

IVES, L. 'Value of the Stern arithmetic apparatus in a backward class'. *British Journal of Educational Psychology.* 1962. 32: 300 - 303.

JARVIS, O. T. 'An analysis of individual differences in arithmetic'. *Arithmetic Teacher.* 1964. 11: 471 - 473.

JOHNSON, G. O. 'Special education for mentally handicapped - a paradox'. *Exceptional Children.* 1962. 19: 62 - 69.

KELLY, F. J., RAINEY, D. S. 'An evaluation of a programmed text with E.M.R. children'. *Exceptional Children.* 1967. 34: 169 - 174.

KIRK, S. Research in Education. In H. STEVENS and R. HEBER (Eds.). Mental Retardation: A review of Research. Chicago: University of Chicago Press. 1964.

KLAUSMEIER, H., FELDHUSEN, J. 'Retention in Arithmetic among children of low, average and high intelligence'. *Journal of Educational Psychology.* 1959. 50: 88 - 92.

KLAUSMEIER, H., CHECK, J. 'Retention and transfer in children of low, average and high intelligence'. *Journal of Educational Resources.* 1962. 55: 7.

LINDSLEY, O. R. 'Direct measurement and prothesis of retarded behaviour'. *Journal of Education.* 1965. 147: 62 - 80.

McINTYRE, R. and DINGHAM, H. 'Mental age vs. learning ability: an investigation of transfer and training between hierarchical levels'. *American Journal of Mental Deficiency.* 1963. 68: 396 - 403.

PRICE, J. 'Automated teaching programs with mentally retarded students'. *American Journal of Mental Deficiency.* 1963. 63: 69 - 72.

SPIVACH, G. and LEVINE, M. 'A note on generality of discrimination deficiency in life long brain damage'. *American Journal of Mental Deficiency.* 1962. 67: 475 - 474.

STERN, C. 'The concrete devices of structural arithmetic'. *Arithmetic Teacher.* 1958. 5: 119 - 130.

TANNER, C. Designs for educational planning, a systemic approach. Lexington, Mass: Heath Lexington Books. 1971.

THURSTONE, T. G. 'An evaluation of educating mentally handicapped children in special and regular grades'. U.S.O.E. Cooperative research program, project #OE SAE - 6452. Chapel Hill: University of North Carolina. 1959.

WHEATLEY, G. H. 'Conservation, cardination and counting as factors in mathematics achievement'. In I. ATHEY and D. RUBADEAU (Eds.). Educational Implications of Piaget's Theory. Toronto: Ginn Blaisdell. 1970. p. 294 - 301.

WOODWARD, M. 'Concepts of number of the mentally subnormal studied by Piaget's method'. *Journal of Child Psychology and Psychiatry.* 1961. 2: 249 - 259.

YOUNG, D. R. 'Network based approach to course development for vocational educators'. *Canadian Vocational Journal.* 1972. 8: 4, 13 - 17.

ZIGLER, E. 'Developmental versus difference theories of mental retardation'. *American Journal of Mental Deficiency.* 1969. 75: 4, 536 - 566.

APPENDIX A

ANNOTATED LIST OF MATERIALS USED IN THE NETWORK PROGRAM

Alberta Correspondence School Modified 7 Alberta Education Edmonton, Alberta	Presents simple concepts in a relatively sophisticated format.
Applying Mathematics Carlow and Raithby 1967 McGraw Hill, & Co. Toronto, Ontario	Problem solving assignments. Teacher made cassette tape accompanies, for non-readers.
Arithmetrics Coronet Instructional Media Chicago, Illinois	Tapes and worksheets. Reviews addition and subtraction.
Basic Elementary Mathematics Educational Sensory Programming Inc.1972 Jones Boro, Arkansas	Tapes and worksheets. Provides practice in elementary operations.
Beginning Maths Concepts 1973 Society for Visual Education Inc. Chicago, Illinois	Tapes and film strips. Needs supplementing with teacher made worksheet.
Computapes Science Research Associates 1972 Toronto, Ontario	Tapes and worksheets. Covers basic operations with whole numbers, fractions, decimals and percents.
Cyclo-teacher Field Enterprises Educational Corp Chicago, Illinois	A simple wheel-like machine that gives immediate reinforcement to student. Commercially produced or teacher made assignments possible.
Decimal Workshop 1976 Coronet Instructional Media Ltd. Markham, Ontario	Tapes and worksheets.
It's a Metric World Addison-Wesley (Canada) Ltd. Don Mills, Ontario	Tapes and film strips. For group instruction useful for introduction or review of metric measure.
Flash-x Cards McGraw Hill Ryerson Ltd. Scarborough, Ontario	A tachistoscope-type of machine. Useful for rote learning of number facts.

Formula I Math Power Pac, Lola J. May 1971 Imperial International Learning Corp. Kankakee, Illinois	Tapes and worksheets: Useful for review of four basic operations with whole numbers.
Fractions and Fractional Numbers George A. Spooner 1971 Milton Bradley Co. Springfield, Massachusetts	Tapes, worksheets and manipulative materials. Introduction to fractions.
Fractions: A New Approach 1974 Society for Visual Education Inc. Chicago, Illinois	Film strips and tapes. Useful for review of fractional numbers.
Inches and Fractions Decimals and Centimetres Encyclopedia Brittanica Publications Ltd. Toronto, Ontario	Film strips, tapes activity materials. Supplemented by teacher made worksheets.
Math Imagination Steve and Janis Marcy 1973 Creative Publications Inc. Palo Alto, California	Interesting puzzle-type assignments, giving practice in basic operations with both whole and fractional numbers.
Mastering Arithmetic Facts Ervin Marriot 1972 Charles E. Merrill Publishing Co. Columbus, Ohio	Tapes and worksheets. Simple format, useful for low functioning students.
Maths Mystery Theatre William J. Dunne Imperial International Learning Corp. Kankakee, Illinois	Film strip, tapes and worksheet. Provides high-interest material for higher functioning students.
Merrill Mathematics Skilltapes Francis T. Sganga 1969 Charles E. Merrill Publishing Co. Columbus, Ohio	Tapes and worksheets. Useful for review of total program. Not suitable for lower functioning students.
Programmed Mathematics (1973) Educational Sensory Programming Inc. Jones Boro, Arkansas	Tapes and worksheets. For practice in rote learning of number facts.
Telling Time Encyclopedia Brittanica Publications Ltd. Toronto, Ontario	Film strips, tapes and activity materials. Supplemented by teacher made worksheets.

Schoolhouse Mathematics 1 (1975) Schoolhouse Mathematics 2 (1976) Science Research Associates (Canada) Ltd. Toronto, Ontario	Self-correcting cards, covers simple number concepts, measuring and geometry. Useful for extremely low functioning students.

Teacher made Materials

Slides Flash Cards Language Master Cards	This material is made up into 'learning packs'. Each pack gives students a variety of media for committing to memory a group of related number facts.

APPENDIX B

M A N U A L

FOR

M A T H E M A T I C S   S K I L L   T E S T S

L E V E L S   1, 2, & 3

Revised January 1977

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Steering Committee

Pupil Assessment Consultant

Mrs. I. Evans	Teacher, L. Y. Cairns
Mr. R. Holt	Elementary Mathematics Consultant
Mr. J. Murray	Teacher, Brightview
Mrs. M. Starko	Elementary Mathematics Consultant
Mrs. S. Tanasichuk	Special Education Consultant

Construction Committee

Pupil Assessment Consultant

Mrs. D. Belair	Teacher, North Edmonton
Mrs. I. Evans	Teacher, L. Y. Cairns
Mrs. A. Irvine	Teacher, L. Y. Cairns
Mrs. E. Kupchenko	Teacher, L. Y. Cairns
Mr. J. Murray	Teacher, Brightview
Mrs. S. Tanasichuk	Special Education Consultant

Review Committee

L. Y. Cairns Mathematics Department

Mr. R. Holt	Elementary Mathematics Consultant
Mrs. M. Starko	Elementary Mathematics Consultant
Mrs. S. Tanasichuk	Special Education Consultant

Pupil Assessment Consultant

Dr. A. L. Charette	Supervisor, Special Education

II INTRODUCTION

In the spring of 1975, a decision was made by Special Education Personnel to develop a series of mathematics tests that could be used to assess some of the skill areas in mathematics covered in some special education programs. In October 1975 the Steering Committee met to develop guidelines and to plan the content and form of the tests. The objectives to be tested were selected and set into three strands: Operations and Properties, Number and Numeration, and Application. It was determined that three tests would be developed, to assess objectives designated at three levels of difficulty.

A complete listing for each of the three test levels of the objectives found in each of the three strands is included on pages 6 to 8. The grade level in the regular E.P.S.B. Mathematics Program at which the objective is introduced is given also.

GUIDELINES FOR USE OF TEST

The Mathematics Skill Tests based on L. Y. Cairns Maths program, 1976, have been divided into three levels with each level sampling three grade levels. These tests are by no means comprehensive in that only some of the objectives covered in the program have been included, but the ones selected were felt to be the most important.

The objectives being tested are organized into the following levels and clusters:

LEVEL	OBJECTIVES	CLUSTERS	GRADE LEVEL (Approx)
1	operations	3	1, 2, 3
	numeration	3	1, 2, 3
2	operations	4	2, 3, 4
	numeration	1	
	application	1	
3	operations	5	4, 5, 6
	application	2	
	numeration	1	
	numeration & application	1	

It is hoped the Mathematic Survey Tests will provide teachers with some guidance in determining the levels and objectives needed to be covered in their mathematics programs. In order to facilitate this there is included, in the manual, a listing of the objectives being tested at each level. The number preceding each objective indicates its position on the master list found on pages four to six.

A grade level is indicated on the extreme right hand column of the master list which specifies the grade at which the objective is introduced in the Edmonton Public School Board Mathematics Program.

When analyzing the students test results attention should be paid to the level of achievement on each cluster. If the student does poorly on a cluster the grade level can be established for the objectives within the cluster by referring to the master list. After establishing a grade level for the objective it will be possible to refer to the Elementary Mathematics Program book at the appropriate grade level and use any or all of the exercises which are felt will help teach and reinforce the particular objective.

For example: A student did poorly on Cluster 3 (numeration) of the Level One Test with mistakes on objective 3 (orders using "greater than", "less than", and "equal" 1 through 999). The teacher, by looking at the master list, will find that the skills for this objective are taught at the grade two level. Pages 13 and 14 of the Level B Book of the Elementary Mathematics Program specifies activities and exercises which can be used to teach and provide reinforcement for this particular objective. Any or all of the exercises on these pages may be assigned to the student, depending on the amount of practice or reinforcement it is felt the child will require in order to master the objective. Each of the clusters maybe approached and analyzed in this way.

Students in Primary Classes will probably need to be tested on Level 1 of the Mathematics Skill Test, students in Junior classes at Level 1 or 2 and students at L. Y. Cairns on Level 2 or 3. However, it is recommended that teachers become familiar with all levels of the test and administer the level which is felt will best assess their students. If a child scores over 80 percent on one level then the next level of the test should be administered.

Further questions regarding the use and administration of the Mathematics Skill Tests may be directed to either Shirleyanne Michaels, Consultant, Pupil Assessment (429-5621), extension 561) or Shirley Ta asichuk, Consultant, Special Education (429-5621, extension 552).

OPERATIONS & PROPERTIES		LEVEL	GRADE
1.	Number facts of + and -. Sums and Minuends to 9	1	1
2.	Number facts of + and -. Sums and Minuends to 18	2	2
3.	Related sentences to 18, e.g. $2 + 3 = 5$, $3 + 2 = 5$ $5 - 3 = 2$, $5 - 2 = 3$	2	2
4.	Use commutative principle to 18, e.g. $8 + 6 = 6 + 8$	2	No Objective (2)
5.	Use associative principle of addition e.g. $(8 + 2) + 3 = 8 + (2 + 3)$	2	No Objective (2&3)
6.	Identity element of + and - (use of 0) $6 + 0 = 6$, $6 - 0 = 6$	1	No Objective (3)
7.	Addition of 2 and 3 digit numbers without regrouping	1	2
8.	Subtraction of 2 and 3 digit numbers without regrouping	1	2
9.	Addition of 2 and 3 digit numbers with regrouping	2	3
10.	Subtraction of 2 and 3 digit numbers with regrouping	2	3
11.	Master multiplication facts to 45	1	3
12.	Use commutative principle of multiplication	2	No Objective (3)
13.	Introduce multiplication facts to 81	2	4
14.	Master multiplication facts to 81	3	4
15.	Identity element in multiplying by 1	2	No Objective (3)
16.	Multiplying by 0	2	No Objective (3)
17.	Multiplication Algorithm without regrouping, 1 digit multiplier	2	3
18.	Multiplication Algorithm with regrouping, 1 digit multiplier	3	3
19.	Master division facts to 81	3	4
20.	Related sentences of multiplication and division	3	3&4
21.	Multiplication by 10s, 100s, 1000s	3	3&4
22.	Multiplication Algorithm with and without regrouping, 2 and 3 digit multipliers	3	4
23.	Division by 1 digit divisor without remainder	3	4
24.	Division by 1 digit divisor with remainder	3	4
25.	Division by 2 and 3 digit divisor with remainder	3	5&6
26.	Adding and subtracting decimals	3	4&5
27.	Multiplying and dividing decimals by whole numbers	3	5&6

NUMBER & NUMERATION		LEVEL	GRADE
1.	Reads, writes and orders numerals 1 through 99	1	1
2.	Identifies the terms between, after, and before 1 through 99	1	1
3.	Orders using "greater than," "less than," and "equal" 1 through 99 (no symbols)	1	1
4.	Reads, writes, and orders numerals 1 through 99	2	1
5.	Identifies the terms between, after, and before 1 through 999	2	2
6.	Orders using "greater than," "less than," and "equal" 1 through 999	2	2
7.	Counting by 2s and 10s	1	2
8.	Counting by 5s and 100s	2	2
9.	Reads, writes, and orders numerals 1 through 100,000	3	3&4
10.	Identifies the terms between, after, and before 1 through 100,000	3	3&4
11.	Orders using "greater than," "less than," and "equal" 1 through 100,000	3	3&4
12.	Recognizes and constructs number lines based on whole numbers	1	(Not in program)
13.	Orders using "greater than," "less than," and "equal" decimal numbers (0.10, 0.01, 0.001)	3	6
14.	Recognizes number places - ones and tens	1	1
15.	Recognizes number places - ones, tens, hundreds, thousands	2	2
16.	Recognizes number places - 10 thousands and 100 thousands	3	3&4
17.	Recognizes number places - 0.1, 0.01	3	4
18.	Identifies from physical objects, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{2}{3}$, $\frac{3}{4}$, tenths, eighths	3	3
19.	Write those fractions	3	4
20.	Recognition of equivalent fractions	3	4
21.	Understand order of common fractions	3	4
22.	Able to use mixed numerals to represent physical objects	3	5&6
23.	Add and subtract fractions with the same denominator	3	6
24.	Finding fractional parts of a group	3	6

NUMBER & NUMERATION (Cont'd)

		LEVEL	GRADE
25.	Changing common fractions to decimals $(\frac{1}{4}, \frac{1}{3}, \frac{1}{2}, \frac{1}{5}, \frac{1}{10}, \frac{1}{100})$	3	5
26.	Changing decimals to common fractions	3	5
27.	Rounding off decimals (limit - to two places)	3	4&5

APPLICATIONS

		LEVEL	GRADE
1.	Determines the operation to be used in a problem. (+, -, x)	2	3&4
2.	Is able to select the number story that represents the problem. (+, -, x)	2	3&4
3.	Able to tell time to the nearest 15 minutes	2	2&3
4.	Solve simple number problems. (all operations +, -, x, ÷)	3	4
5.	Tells time to nearest minute	3	4
6.	Solves money problems involving both dollars and cents	3	4
7.	Solves common direct measurement problems	3	5&6

<u>NOTE</u> - "No objective" (grade) means this skill is taught in the bracketed grade in the regular program but not tested.

"Not in program" means this skill is NOT taught in the regular Edmonton Public School Board Mathematics Program.

III TEST CONSTRUCTION

Early in November, the Test Construction Committee met to construct test questions according to the test blueprints. The questions were placed on test forms. These test forms were then reviewed by members of the Review Committee who checked the validity of individual questions.

IV CLUSTER GROUPINGS

The following is a specific breakdown of the objectives being assessed on each of the Mathematics Skill Tests, Level 1, Level 2, and Level 3. The cluster name indicates the strand from which each objective was taken.

A. MATHEMATICS SKILL TEST - LEVEL 1

CLUSTER 1: OPERATIONS AND PROPERTIES

Objectives covered:

1. Number facts of + and -. Sums and Minuends to 9

Number of Questions: 10

Question Numbers: 1 - 10

CLUSTER 2: NUMBER AND NUMERATION

Objectives covered:

1. Reads, writes, and orders numerals 1 through 99

Number of Questions: 6

Question Numbers: 11 - 16

CLUSTER 3: NUMBER AND NUMERATION

Objectives covered:

2. Identifies the terms between, after, and before 1 through 99

3. Orders using "greater than," "less than," and "equal" 1 through 99

12. Recognizes and constructs number lines based on whole numbers.

Number of Questions: 7

Question Numbers: 17 - 23

CLUSTER 4: NUMBER AND NUMERATION

Objectives covered:

7. Counting by 2s and 10s

14. Recognizes number places - ones and tens

Number of Questions: 6

Question Numbers: 24 - 29

CLUSTER 5: OPERATIONS AND PROPERTIES

Objectives covered:

6. Identity element of + and - (use of 0) 6 + 0 = 6, 6 - 0 = 6

7. Addition of 2 and 3 digit numbers without regrouping

8. Subtraction of 2 and 3 digit numbers without regrouping

Number of Questions: 8

Question Numbers: 30 - 37

CLUSTER 6: OPERATIONS AND PROPERTIES

Objectives covered:

2. Number facts of + and -. Sums and Minuends to 18 (not timed)

9. Addition of 2 and 3 digit numbers with regrouping

10. Subtraction of 2 and 3 digit numbers with regrouping

Number of Questions: 8

Question Numbers: 38 - 45

B. MATHEMATICS SKILL TEST - LEVEL 2

CLUSTER 1: OPERATIONS AND PROPERTIES

Objectives covered:

2. Number facts of + and -. Sums and Minuends to 18 (timed)

11. Master multiplication facts to 45 (timed)

Number of Questions: 10

Question Numbers: 1 - 10

CLUSTER 2: NUMBER AND NUMERATION

Objectives covered:

15. Recognizes number places ones, tens, hundreds, thousands

4. Reads, writes, and orders numerals 1 through 999

5. Identifies the terms between, after, and before 1 through 999

6. Orders using "greater than,"less than," and "equal" 1 through 999

8. Counting by 5s and 100s

Number of Questions: 7

Question Numbers: 11 - 17

CLUSTER 3: OPERATIONS AND PROPERTIES

Objectives covered:

9. Addition of 2 and 3 digit numbers with regrouping

10. Subtraction of 2 and 3 digit numbers with regrouping

17. Multiplication Algorithm without regrouping, 1 digit multiplier

Number of Questions: 8

Question Numbers: 18 - 25

CLUSTER 4: OPERATIONS AND PROPERTIES

Objectives covered:

13. Introduce multiplication facts to 81

Number of Questions: 6

Question Numbers: 26 - 31

CLUSTER 5: APPLICATIONS

Objectives covered:

1. Determines the operation to be used in a problem. (+, -, x)

2. Is able to select the number story that represents the problem (+, -, x)

3. Able to tell time to the nearest 15 minutes

Number of Questions: 8

Question Numbers: 32 - 39

CLUSTER 6: OPERATIONS AND PROPERTIES

Objectives covered:

3. Related sentences to 18, e.g. $2 + 3 = 5$, $3 + 2 = 5$, $5 - 3 = 2$, $5 - 2 = 3$

4. Use commutative principle to 18, e.g. $8 + 6 = 6 + 8$

5. Use associative principle of addition $(8 + 2) + 3 = 8 + (2 + 3)$

12. Use commutative principle of multiplication

15. Identity element in multiplying by 1

16. Multiplying by 0

Number of Questions: 7

Question Numbers: 40 - 46

C. MATHEMATICS SKILL TEST - LEVEL 3

CLUSTER 1: OPERATIONS AND PROPERTIES

Objectives covered:

14. Master multiplication facts to 81 (timed)

Number of Questions: 10

Question Numbers: 1 - 10

CLUSTER 2: OPERATIONS AND PROPERTIES

Objectives covered:

19. Master division facts to 81

Number of Questions: 10

Question Numbers: 11 - 20

CLUSTER 3(a):

Objectives covered:

NUMBER AND NUMERATION

9. Reads, writes, and orders numerals 1 through 100,000

11. Orders using "greater than," "less than," and "equal" 1 through 100,000

16. Recognizes number places - 10 thousands and 100 thousands

OPERATIONS AND PROPERTIES

20. Related sentences of multiplication and division

Number of Questions: 3

Question Numbers: 21 - 23

CLUSTER 3(b): OPERATIONS AND PROPERTIES

Objectives covered:

18. Multiplication Algorithm with regrouping, 1 digit multiplier

21. Multiplication by 10s, 100s, and 1000s

22. Multiplication Algorithm with and without regrouping, 2 and 3 digit multipliers

Number of Questions: 6

Question Numbers: 24 - 29

CLUSTER 4: OPERATIONS AND PROPERTIES

Objectives covered:

23. Division by 1 digit divisor without remainder

24. Division by 1 digit divisor with remainder

25. Division by 2 and 3 digit divisor with remainder

Number of Questions: 6

Question Numbers: 30 - 35

CLUSTER 5: APPLICATIONS

Objectives covered:

4. Solve simple number problems. (all operations +,−,x,÷)
5. Tells time to nearest minute

Number of Questions: 6

Question Numbers: 36 - 41

CLUSTER 6: NUMBER AND NUMERATION

Objectives covered:

18. Identifies from physical objects $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{2}{3}$, $\frac{3}{4}$, tenths, eighths
19. Write those fractions
20. Recognition of equivalent fractions
21. Understand order of common fractions
22. Able to use mixed numerals to represent physical objects
23. Add and subtract fractions with the same denominator
24. Finding fractional parts of a group

Number of Questions: 8

Question Numbers: 42 - 49

CLUSTER 7:

Objectives covered:

NUMBER AND NUMERATION

17. Recognizes number places - 0.1, 0.01
25. Changing common fractions to decimals - $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{1}{5}$, $\frac{1}{10}$, $\frac{1}{100}$
26. Changing decimals to common fractions
27. Rounding off decimals (limit - to two places)

OPERATIONS AND PROPERTIES

26. Adding and subtracting decimals
27. Multiplying and dividing decimals by whole numbers

Number of Questions: 8

Question Numbers: 50 - 57

CLUSTER 8: APPLICATIONS

Objectives covered:

6. Solves money problems involving both dollars and cents
7. Solves common direct measurement problems

Number of Questions: 6

Question Numbers: 58 - 63

V DIRECTIONS FOR ADMINISTRATION

A. MATHEMATICS SKILL TEST - LEVEL 1

The time required to administer the Level 1 test is as follows:

PART ONE		PART TWO	
CLUSTER 1:	1 minute (timed)	CLUSTER 5:	10 minutes (approx.)
2:	6 minutes (approx.)	6:	5 minutes (approx.)
3:	7 minutes (approx.)		15 minutes
4:	6 minutes (approx.)		
	20 minutes		

Except for timed sections, the time guidelines should be used as approximations of the time needed for the student to complete the section. On untimed sections, students should have a reasonable amount of time to try and complete all questions in the section.

VERBAL SCRIPT

Have the students complete the information on the front page of the test booklet, and write name on pages 1 and 2.

CLUSTER 1 - page 1

Cluster 1 is timed. Allow one minute for completion of the page.

You will be doing some addition and subtraction problems.
We will do Sample A together.

Sample A: One and one are

Give the students time to do the question. Ask for the correct answer.

Now do the next 10 questions. You have one minute to work on this page.

Teacher collects page 1 after checking that student's name is written on the top of the page.

CLUSTER 2 - page 2

These are counting questions. Put the missing numbers in the boxes. Stop working when you have completed question 16.

11-
16 Allow time for students to complete page 2.

CLUSTER 3 - page 3

17. *Look at this number. What number comes before? Put the correct number in the box.*

18. *Look at this number. What number comes next? (after) Put the correct number in the box.*

19. *Look at these number stories. Circle the one that is correct.*

20. Find question 20 at the top of the page. Look at these numbers. Put a circle around the lesser (smaller) number.

21. Look at these numbers. Put a circle around the greater (bigger) number.

22. This is a number line. Put the missing number in the box.

23. Look at the numbers. What number comes between? Put the correct number in the box.

CLUSTER 4 - page 4

24. Look at this picture. How many tens, and how many ones? Put the number of tens in the tens box and the number of ones in the ones box.

25. Look at this picture. How many tens and how many ones? Put the number of tens in the tens box and the number of ones in the ones box.

26. Look at the dots. How many tens and how many ones? Put the numbers in the boxes.

27. Look at this number. Put a circle around the number that tells how many 10s.

28. Look at this way of counting. What comes next? Put the correct numbers in the boxes.

29. Look at this way of counting. What comes next? Put the correct numbers in the boxes.

CLUSTER 5 - page 5

30. Put the correct number in the box.

31. Put the correct number in the box.

32- 37. The next six questions require you to add or subtract. Complete these questions, being careful to watch the sign. Stop working when you have completed question 37.

CLUSTER 6 - page 6

This section is not timed - student reads question to himself.

38- 45. Now we will do some more addition and subtraction problems. Put the correct answers in the boxes. Stop working when you have completed question 45.

B. MATHEMATICS SKILL TEST - LEVEL 2

The time required to administer the Level 2 test is as follows:

PART ONE		PART TWO	
CLUSTER 1:	1 minute (timed)	CLUSTER 4:	6 minutes (approx.)
2:	7 minutes (approx.)	5:	15 minutes (approx.)
3:	15 minutes (approx.)	6:	7 minutes (approx.)
	23 minutes		28 minutes

Except for timed sections, the time guidelines should be used as approximations of the time needed for the student to complete the section. On untimed sections, students should have a reasonable amount of time to try and complete all questions in the section.

VERBAL SCRIPT

Have the students complete the information on the front page of test booklet, and write their name on page 1 and page 2.

CLUSTER 1 - page 1

Cluster 1 is timed. The tester reads the sample question and then starts the students on the remaining questions. The tester should have available a watch with a second hand so the timing can be done accurately.

We will start with some addition, subtraction and multiplication problems. As soon as I say start, begin with question 1 and work as quickly as possible. Put the correct answer in the box. Pay careful attention to the signs. Before we start, let's solve Sample A. Put the correct answer in the box.

Give the students time to do the question. Ask for the correct answer.

1- 10. *Yes 12 is the correct answer. Do the following questions in the same way. Stop when you have completed question 10. Start this section of the test. You have one minute to work on this page.*

Allow 1 minute for this section of the test. Collect the sheet after making sure the student's name is included.

CLUSTER 2 - page 2

This is not a timed section. Teacher reads only the directions and allows a reasonable amount of time for each question.

11. *Look at the number written in words. Write the number in the box.*
12. *Put the missing number in the box.*
13. *This is counting. Put the missing number in the box.*
14. *This is counting. Put the missing number in the box.*
15. *Put the number in the box that comes before 400.*
16. *Circle the correct answer.*
17. *Put the number of hundreds, tens, and ones shown in the picture in the boxes.*

CLUSTER 3 - page 3

18- *Work this page of problems. Remember to watch the signs. Stop*
25. *working when you have completed question 25.*

Allow time for students to complete as much as possible.

CLUSTER 4 - page 4

This is not a timed section. Students should be permitted a reasonable amount of time to complete this cluster.

26- *Do the following questions. Stop when you have completed question 31.*
31. *Start this section of the test.*

CLUSTER 5 - pages 5, 6, and 7

This cluster may be administered in either of two ways, depending upon the ability of your class. The students may be required to read and complete the problems independently (with the teacher giving individual reading assistance wherever necessary); or the teacher may read the entire problem to the class and then allow them a reasonable amount of time to complete the answer. Students should not be penalized because of poor reading skills.

For teachers reading the questions the following script is given:

32. *Put a circle around the correct number story.*

33. *Put a circle around the correct number story.*

34. *Put a circle around the correct number story.*

35. *Circle the correct number story and put the answer in the box.*

36. *Circle the correct number story and put the answer in the box.*

37. *Circle the correct number story and put the answer in the box.*

38. *Draw the hands to show 10:30 on the clock.*

39. *Write the correct time in the box.*

CLUSTER 6 - page 8

40- *Put the missing numbers into the questions on this page. Stop*
46. *when you have completed question 46. Start this section of the test.*

C. MATHEMATICS SKILL TEST - LEVEL 3

The time required to administer this test is as follows:

PART ONE		PART TWO	
CLUSTER 1:	2 minutes (timed)	CLUSTER 6:	7 minutes (approx.)
2:	2 minutes (timed)	7:	8 minutes (approx.)
3:	9 minutes (approx.)	8:	10 minutes (approx.)
4:	7 minutes (approx.)		
5:	10 minutes (approx.)		
	30 minutes		25 minutes

Except for timed sections, the time guidelines should be used as approximations of the time needed for the student to complete the section. On untimed sections, students should have a reasonable amount of time to try and complete all questions in the section.

VERBAL SCRIPT

Have each student complete the information on the front page of the test booklet, and write his/her name on page 1, 2, and 3.

CLUSTER 1 - page 1

Cluster 1 is timed. The tester reads the sample question and then starts the students on the remaining questions. The tester should have available a watch with a second hand so the timing can be done accurately. Collect the page on which the questions for this cluster are typed before starting the next cluster of questions on the test.

We will start with some multiplication problems. As soon as I say start, begin with question 1 and work as quickly as possible. Put the correct answer in the boxes. Pay careful attention to the signs. Before we start, let's solve Sample A. Put the correct answer in the box.

Give students time to do the question. Ask for the correct answer.

1- *Yes, 12 is the correct answer. Do the following questions in the*
10. *same way. Stop when you have completed question 10. Start this section of the test. You have two minutes to work on this page.*

Allow two minutes. After two minutes say:

Stop this section of the test.

CLUSTER 2 - page 2

Cluster 2 is timed.

11- *Now we will do some division problems. Do the 10 questions on*
20. *page 2. Stop when you have completed question 20. Start this section of the test. You have two minutes to work on this page.*

Allow two minutes. After two minutes say:

Stop this section of the test.

Then collect pages 1 and 2. Make sure student's name is written.

CLUSTER 3(a) - page 3 only

This is not a timed section.

Look at Sample B. There are four related number sentences. Now look at the three related number sentences in question 21.

21. *Put the missing related number sentence in the box.*

22. *Look at the number sixty-five thousand, 7 hundred and forty-one. Write the number in the box that is in the ten thousands place.*

23. *Write the greater (larger) number in the box.*

CLUSTER 3(b) - page 4 only AND CLUSTER 4 - page 5 CALCULATIONS

This is not a timed section. Students should have a reasonable amount of time to complete the section. Questions included in the two sections are Cluster 3(b) - 24-29 and Cluster 4 - 30-35.

24-29. 30-35. *Questions 24 to 29 are multiplication problems. Questions 30 to 35 are division problems. Complete these questions carefully, working as quickly as possible. Stop when you have completed question 35. Start these questions.*

CLUSTER 5 - pages 6 and 7

This is not a timed section. You may read individual problems to students if they request assistance.

36-41. *Answer these questions. If you need help with the reading, put your hand up.*

CLUSTER 6 - pages 8 and 9.

These questions may be read to the student if lack of reading skills would penalize his performance.

42-49. *Do problems 42 to 49. Put your hand up if you have trouble reading the questions.*

CLUSTER 7 - pages 10 and 11

This is not a timed section.

50. *What is the fraction that has the same value as $\frac{5}{10}$? Circle the correct answer.*

51. *What is the fraction that has the same value as 0.02? Circle the correct answer.*

52-57. *For questions 52 to 57, put the correct answer in the box.*

CLUSTER 8 - pages 12, 13, and 14

This is not a timed section. You may read individual problems to students if they request assistance.

58-63. *For questions 58 to 63, put the number story (equation) and answer in the box.*

VI SCORING PROCEDURES

Upon completion of testing, test booklets should be collected, and scored according to the appropriate key.

A. KEY FOR MATHEMATICS SKILL TEST - LEVEL 1

Sample A = 2

CLUSTER 1:

1. 1
2. 9
3. 5
4. 7
5. 2
6. 8
7. 5
8. 3
9. 3
10. 9

CLUSTER 2:

11. Missing number is 93
12. Missing number is 17
13. Missing number is 80
14. Missing number is 30
15. Missing number is 62
16. Missing number is 10

CLUSTER 3:

17. Number that comes before is 39.
18. Number that comes next is 20.
19. The number story that is correct is 69 = 69.
20. The smaller number is 59.
21. The greater number is 31.
22. The missing number is 6.
23. The number that comes between is 30.

CLUSTER 4:

24. 3 tens and 4 ones
25. 6 tens and 0 ones
26. 3 tens and 5 ones
27. The number that tells how many 10s is 4.
28. The numbers coming next are 60 and 70. (Both answers must be correct.)
29. The numbers coming next are 30 and 32. (Both answers must be correct.)

CLUSTER 5:

30. 9
31. 6
32. 31
33. 26
34. 52
35. 79
36. 89
37. 99

CLUSTER 6:

38. 14
39. 15
40. 17
41. 17
42. 7
43. 4
44. 1
45. 9

B. KEY FOR MATHEMATICS SKILL TEST - LEVEL 2

Sample A = 12

CLUSTER 1:

1. 14
2. 16
3. 13
4. 6
5. 8
6. 8
7. 16
8. 12
9. 28
10. 45

CLUSTER 2:

11. 346
12. The missing number is 892.
13. The missing number is 450.
14. The missing number is 55.
15. 399
16. 897 is greater than 798
17. 4 hundreds, 7 tens, 3 ones

CLUSTER 3:

18. 161
19. 411
20. 229
21. 1443
22. 84
23. 1219
24. 486
25. 960

CLUSTER 4:

26. 36
27. 48
28. 81
29. 56
30. 63
31. 42

CLUSTER 5:

32. 15 - 6 = 9
33. 74 + 57 = n
34. 5 x 3 = 15 cents
35. 13 - 5 = 8
36. 3 x 20 = 60
37. 25 + 7 = 32
38. draw hands to show 10:30 on clock (Hour hand may be on the 10.)
39. 4:45, 15 minutes to 5 o'clock, or quarter to 5

CLUSTER 6:

40. The missing number is 7.
41. The missing number is 8.
42. The missing number is 7.
43. 0
44. 1
45. The missing number is 7.
46. The missing number is 1.

C. KEY FOR MATHEMATICS SKILL TEST - LEVEL 3

Sample A = 12

CLUSTER 1:

1. 48
2. 63
3. 56
4. 54
5. 42
6. 49
7. 72
8. 28
9. 64
10. 27

CLUSTER 2:

11. 6
12. 2
13. 5
14. 4
15. 5
16. 7
17. 8
18. 9
19. 8
20. 9

CLUSTER 3(a):

21. $15 \div 3 = 5$
22. 6
23. 75,835

CLUSTER 3(b):

24. 9,051
25. 52,731
26. 68,056
27. 1,010
28. 32,000
29. 17,000

CLUSTER 4:

30. 4 2r
31. 9 3r
32. 23 2r
33. 305
34. 632 3r
35. 348 4r

CLUSTER 5:

36. 96
37. 8 kg (unit optional)
38. 5
39. 810 kg (unit optional)
40. 5:12 or 12 minutes after 5
41. Draw hands to show 10:37 on the clock. Hour hand must be between 10 and 11.

CLUSTER 6:

42. Shade in $\frac{3}{4}$ of the shape.
43. $\frac{7}{10}$
44. Missing numbers $\frac{1}{2} = \frac{2}{4} = \frac{4}{8}$ (all must be correct)
45. $\frac{1}{4}, \frac{1}{3}, \frac{1}{2}$
46. $\frac{5}{3}$ or $1\frac{2}{3}$
47. $\frac{3}{5}$
48. $\frac{3}{10}$
49. Draw 2 in the box.

CLUSTER 7:

50. 0.5
51. $\frac{2}{100}$
52. 14.8
53. 15
54. 72.4
55. 16.77
56. 7.623
57. \$15.06

CLUSTER 8:

58. \$1.37
59. \$3.75
60. \$14.25
61. $3\frac{1}{2}$ or $3\frac{2}{4}$
62. $13\frac{21}{10}$ or $15\frac{1}{10}$
63. $3\frac{1}{2}$ or $3\frac{2}{4}$

NAME ______________________________

SCHOOL ______________________________

MATHEMATICS SKILL TEST

LEVEL I

March, 1976

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MATHEMATICS SKILL TEST

LEVEL I

NAME ______________________________

Sample A

1 + 1 = $\square$

1.

$6 - 5 =$ $\square$

6.

$6 + 2 =$ $\square$

2.

$4 + 5 =$ $\square$

7.

$8 - 3 =$ $\square$

3.

$7 - 2 =$ $\square$

8.

$9 - 6 =$ $\square$

4.

$4 + 3 =$ $\square$

9.

$8 - 5 =$ $\square$

5.

$9 - 7 =$ $\square$

10.

$8 + 1 =$ $\square$

Cluster One Total = $\square$

2 NAME ______________________________

Put the missing numbers in the boxes. Stop working when you have completed question 16.

11. 92, $\square$, 94, 95

12. 15, 16 , $\square$, 18, 19

13. 78, 79, $\square$, 81

14. 28, 29, $\square$, 31, 32

15. 59, 60, 61, $\square$

16. 8, 9, $\square$, 11

3

17.

☐ , 40

20.

63, 59

18.

19, ☐

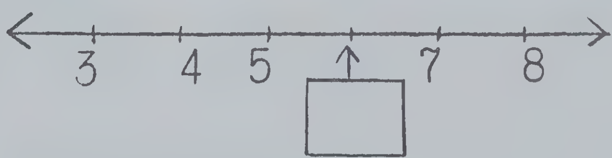
21.

13, 31

19.

69 = 68
69 = 67
69 = 69

22.

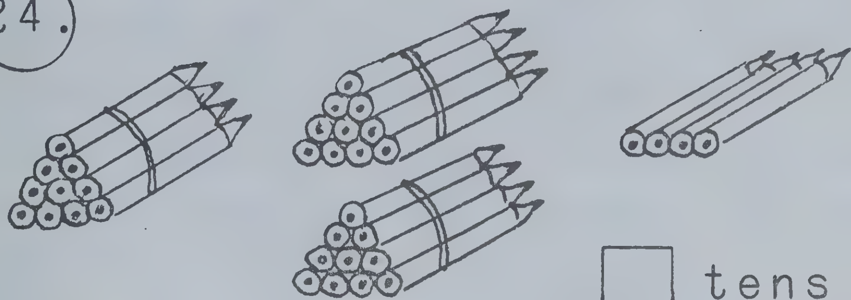


23.

29, ☐ , 31

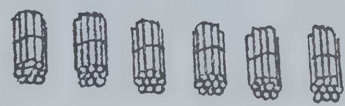
Cluster Three Total = ☐

(24.)



☐ tens ☐ ones

(25.)



☐ tens ☐ ones

(26.)

☐ tens ☐ ones

(27.)

48

(28.)

20, 30, 40, 50, ☐ , ☐

(29.)

22, 24, 26, 28, ☐ , ☐

Cluster Four Total = ☐

The next six questions require you to add or subtract. Complete these questions, being careful to watch the sign. Stop working when you have completed question 37.

30.

$$\begin{array}{r} 9 \\ -0 \\ \hline \end{array}$$

☐

31.

$6 + 0 =$ ☐

32.

$$\begin{array}{r} 76 \\ -45 \\ \hline \end{array}$$

☐

33.

$$\begin{array}{r} 28 \\ -\ \ 2 \\ \hline \end{array}$$

☐

34.

$$\begin{array}{r} 87 \\ -\ 35 \\ \hline \end{array}$$

☐

35.

$$\begin{array}{r} 54 \\ +25 \\ \hline \end{array}$$

☐

36.

$$\begin{array}{r} 57 \\ +\ 32 \\ \hline \end{array}$$

☐

37.

$$\begin{array}{r} 38 \\ +\ 61 \\ \hline \end{array}$$

☐

6

Now we will do some more addition and subtraction problems. Put the correct answers in the box. Stop working when you have completed question 45.

38.

$$\begin{array}{r} 8 \\ 4 \\ +2 \\ \hline \boxed{} \end{array}$$

39.

$7 + 5 + 3 = \boxed{}$

40.

$$\begin{array}{r} 14 \\ +\ 3 \\ \hline \boxed{} \end{array}$$

41.

$11 + 6 = \boxed{}$

42.

$$\begin{array}{r} 15 \\ -\ 8 \\ \hline \boxed{} \end{array}$$

43.

$13 - 9 = \boxed{}$

44.

$$\begin{array}{r} 16 \\ -15 \\ \hline \boxed{} \end{array}$$

45.

$17 - 8 = \boxed{}$

Cluster Six Total = $\boxed{}$

NAME ______________________

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MATHEMATICS SKILL TEST

LEVEL 2

March, 1976

REVISED JANUARY 1977

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MATHEMATICS SKILL TEST

LEVEL 2

NAME ______________________________

Sample A

$5 + 7 = \boxed{}$

(1.) $8 + 6 = \boxed{}$	(6.) $13 - 5 = \boxed{}$
(2.) $7 + 9 = \boxed{}$	(7.) $2 \times 8 = \boxed{}$
(3.) $5 + 8 = \boxed{}$	(8.) $4 \times 3 = \boxed{}$
(4.) $15 - 9 = \boxed{}$	(9.) $4 \times 7 = \boxed{}$
(5.) $17 - 9 = \boxed{}$	(10.) $5 \times 9 = \boxed{}$
	Cluster One Total = $\boxed{}$

2 NAME ______________________

11. three hundred forty-six ☐

12. 891, ☐, 893, 894,

13. 350, ☐, 550, 650

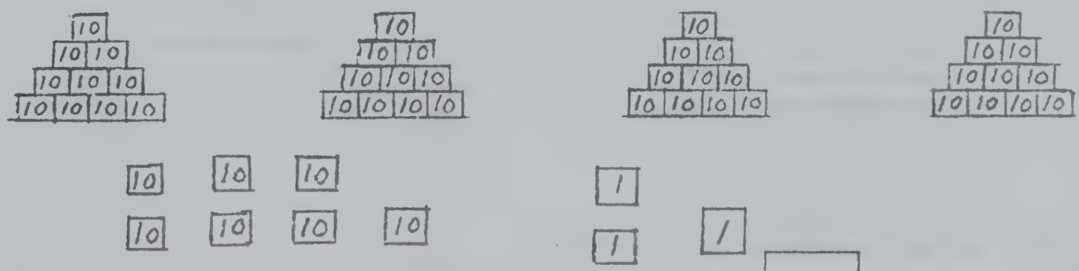
14. 45, 50, ☐, 60

15. ☐, 400, 401, 402

16. Put a circle around the letter of the correct number story.

A. 897 is greater than 798
B. 897 is equal to 798
C. 897 is less than 798

17.



☐ hundreds ☐ tens ☐ ones

18.

$$\begin{array}{r} 83 \\ +78 \\ \hline \end{array}$$

$\boxed{}$

22.

$$\begin{array}{r} 930 \\ -846 \\ \hline \end{array}$$

$\boxed{}$

19.

$$\begin{array}{r} 615 \\ -204 \\ \hline \end{array}$$

$\boxed{}$

23.

$$\begin{array}{r} 432 \\ 129 \\ +658 \\ \hline \end{array}$$

$\boxed{}$

20.

$$\begin{array}{r} 508 \\ -279 \\ \hline \end{array}$$

$\boxed{}$

24.

$$\begin{array}{r} 243 \\ \times\quad 2 \\ \hline \end{array}$$

$\boxed{}$

21.

$$\begin{array}{r} 798 \\ +645 \\ \hline \end{array}$$

$\boxed{}$

25.

$$\begin{array}{r} 320 \\ \times\quad 3 \\ \hline \end{array}$$

$\boxed{}$

Cluster Three Total = $\boxed{}$

26.

$6 \times 6 = \boxed{}$

29.

$8 \times 7 = \boxed{}$

27.

$8 \times 6 = \boxed{}$

30.

$7 \times 9 = \boxed{}$

28.

$9 \times 9 = \boxed{}$

31.

$6 \times 7 = \boxed{}$

Cluster Four Total = $\boxed{}$

32. Tom had 15 candies. He ate 6 candies. How many candies did he have left?

Put a circle around the letter of the correct number story.

A. $15 + 6 = 21$
B. $6 \times 15 = 90$
C. $15 - 6 = 9$

33. Roy had 74 stamps. John had 57 stamps. How many stamps did they have together?

Put a circle around the letter of the correct number story.

A. $74 - 57 = n$
B. $74 + 57 = n$
C. $74 \times 57 = n$

34. If one pencil costs 5 cents, how much will 3 pencils cost?

Put a circle around the letter of the correct number story.

A. $5 + 3 = 8$ cents
B. $5 \times 3 = 15$ cents
C. $5 - 3 = 2$ cents

35. Bob had 13 baseball cards. He lost 5 of them. How many baseball cards does Bob have now? Put a circle around the letter of the correct number story and fill in its box.

A. $13 + 5 = \square$

B. $13 + \square = 5$

C. $\square - 5 = 13$

D. $13 - 5 = \square$

36. Tom bought 3 chocolate bars. Each one cost 20 cents. How much did he spend in all? Put a circle around the letter of the correct number story and fill in its box.

A. $3 + 20 = \square$

B. $3 \times 20 = \square$

C. $\square - 20 = 60$

D. $20 + 3 = \square$

37. Bill had 25 marbles. At recess he won 7 more. How many marbles does Bill have now? Put a circle around the letter of the correct number story and fill in its box.

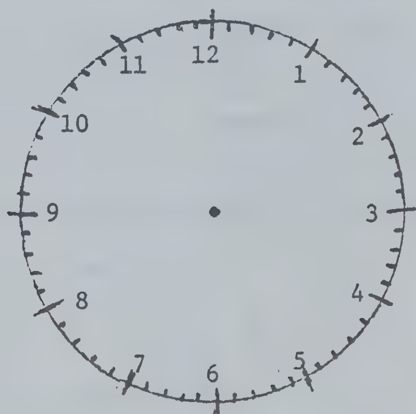
A. 25 x ☐ = 32

B. 25 - 7 = ☐

C. 25 + 7 = ☐

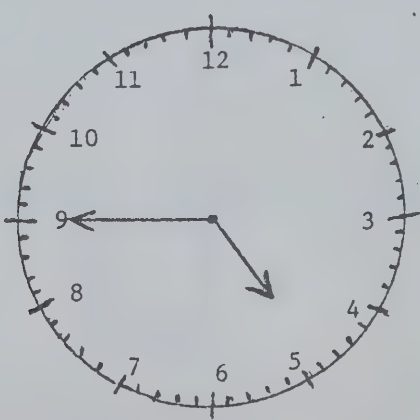
D. 32 - 25 = ☐

38.



10:30

39.



The correct time is

☐

40. $9 + 7 = 16$

$16 - 9 = \boxed{}$

41. $9 + 8 = \boxed{} + 9$

42. $9 \times 7 = \boxed{} \times 9$

43. $2 \times 0 = \boxed{}$

44. $4 \times \boxed{} = 4$

45. $(7 + 3) + 4 = \boxed{} + (3 + 4)$

46. $\boxed{} \times 17 = 17$

Cluster Six Total = $\boxed{}$

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MATHEMATICS SKILL TEST

LEVEL 3

NAME ______________________________

Sample A

6 x 2 = $\boxed{}$

1. $6 \times 8 =$ ☐	6. $7 \times 7 =$ ☐
2. $7 \times 9 =$ ☐	7. $8 \times 9 =$ ☐
3. $8 \times 7 =$ ☐	8. $7 \times 4 =$ ☐
4. $9 \times 6 =$ ☐	9. $8 \times 8 =$ ☐
5. $6 \times 7 =$ ☐	10. $9 \times 3 =$ ☐
	Cluster One Total = ☐

2 NAME ______________________

11. $18 \div 3 = \square$	17. $48 \div 6 = \square$
12. $14 \div 7 = \square$	18. $63 \div 7 = \square$
13. $15 \div 3 = \square$	19. $72 \div 2 = \square$
14. $16 \div 4 = \square$	20. $54 \div 6 = \square$
15. $45 \div 9 = \square$	
16. $56 \div 8 = \square$	Cluster Two Total = $\square$

NAME ______________________________

SCHOOL ______________________________

MATHEMATICS SKILL TEST

LEVEL 3

March, 1976

REVISED JANUARY, 1977

Sample B

$$4 \times 9 = 36$$
$$9 \times 4 = 36$$
$$36 \div 9 = 4$$
$$36 \div 4 = 9$$

21. Put the missing related number sentence in the box.

$$3 \times 5 = 15$$
$$5 \times 3 = 15$$
$$15 \div 5 = 3$$

$\boxed{}$

22. Write the number in the box that is in the ten thousands place.

65,741 $\boxed{}$

23. Write the greater number in the box.

75,649
75,835

$\boxed{}$

24. $\begin{array}{r} 431 \\ \times\ 21 \\ \hline \end{array}$

25. $\begin{array}{r} 567 \\ \times\ 93 \\ \hline \end{array}$

26. $\begin{array}{r} 8507 \\ \times\ \ \ 8 \\ \hline \end{array}$

27. $101 \times 10 =$

28. $320 \times 100 =$

29. $17 \times 1000 =$

Cluster Three Total =

30. $38 \div 9 =$

33. $9 \overline{)2745}$

31. $75 \div 8 =$

34. $7 \overline{)4427}$

32. $4 \overline{)94}$

35. $28 \overline{)9748}$

Cluster Four Total =

36. There are 8 cookies in a box. How many cookies would be in 12 boxes?

37. John Weighs 35 kg and Bill weighs 27 kg. Find the difference between their weights.

38. Tom needs 40 balloons for a party. Balloons are sold in bags of 8. The number of bags that he has to buy is

Circle the correct answer

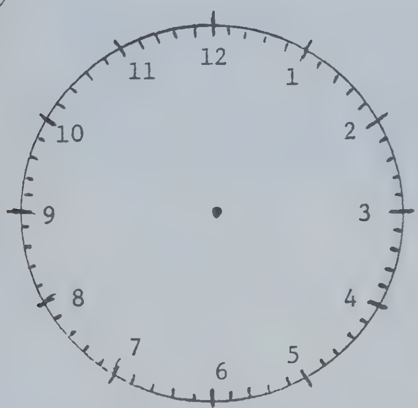
A. 5
B. 6
C. 7
D. 8

39. Tom drove for 2 days. The first day he drove 375 km. The second day he drove 435 km How many kilometres did Tom drive altogether?

40.

What time is it?

41.

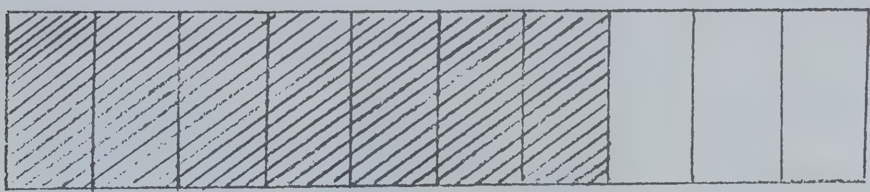


Show 10:37 on the clock. Be sure the hour and minute hands are different lengths.

Cluster Five Total =

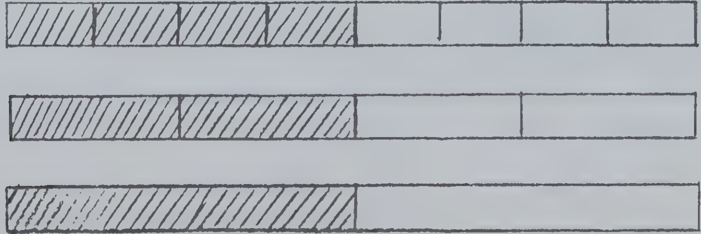
42. Shade in $\frac{3}{4}$ of the shape below.

43. Write the fraction that shows how much of the box is shaded.



$\boxed{}$

44. Use the picture to fill in the missing numerals in the boxes below.

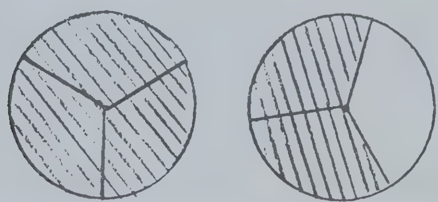


$$\frac{1}{\boxed{}} = \frac{2}{\boxed{}} = \frac{\boxed{}}{8}$$

45. Put these fractions in order, starting with the smallest. Write them in the 3 boxes.

$$\frac{1}{3}, \quad \frac{1}{2}, \quad \frac{1}{4}$$

46. Write a fraction to show the amount shaded.



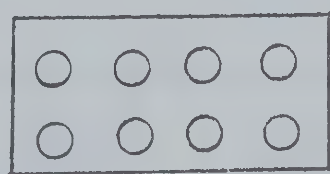
47.

$$\frac{2}{5} + \frac{1}{5} =$$

48.

$$\frac{7}{10} - \frac{4}{10} =$$

49. Draw $\frac{1}{4}$ of this set in the box.



Cluster Six Total =

50. What is the decimal fraction that has the same value as $\frac{5}{10}$? Circle the correct answer.

$$\frac{5}{10} \begin{array}{l} = 0.05 \\ = 5.00 \\ = 0.50 \end{array}$$

51. What is the fraction that has the same value as 0.02?

$$= \frac{2}{100}$$

$$0.02 = \frac{2}{10}$$

$$= 2$$

52. 14.83 rounded to the nearest tenth is $\square$

53. 14.83 rounded to the nearest whole number is $\square$

54.

$$\begin{array}{r} 12.9 \\ +59.5 \\ \hline \end{array}$$

55.

$$\begin{array}{r} \$24.05 \\ -\ 7.28 \\ \hline \end{array}$$

\$

56.

$$\begin{array}{r} 2.541 \\ \times \quad 3 \\ \hline \end{array}$$

57.

$$\begin{array}{r} \$ \\ 3\overline{)\ \$45.18} \end{array}$$

Cluster Seven Total =

58. Mother bought a 5-pound roast for $8.63. Mother paid with a $10.00 bill. How much change did she get?

59. Joe saved $15.00 in 4 weeks to buy a big cowboy hat. Each week he saved the same amount. How much money did he save each week?

60. A man worked 3 hours to fix a radio. At $4.75 an hour, how much was the bill?

61. One recipe calls for $1\frac{3}{4}$ cups of sugar. How much sugar would you use if you doubled the recipe?

62. The family wished to find out how many litres of gas they used in a week. Mother put in $3\frac{7}{10}\ \ell$, John put in $6\frac{5}{10}\ \ell$, and Dad put in $4\frac{9}{10}\ \ell$. How many litres did they put in altogether?

63. Bill wants to make a table and a bench. He bought a board that is $5\frac{3}{4}$ feet long. If Bill cuts $2\frac{1}{4}$ feet off for a table, how much is left for the bench?

Cluster Eight Total =